BULLETIN

OF THE

AMERICAN ASSOCIATION

OF

PETROLEUM GEOLOGISTS

VOLUME 4 NUMBER 3
1920

RAYMOND C. MOORE, Editor

PUBLISHED BY THE ASSOCIATION

CONTENTS

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

OFFICERS FOR 1920

WALLACE E. PRATT, *President*
Fort Worth, Texas

ALEX W. MCCOY, *Vice-President*
Bartlesville, Oklahoma

CHARLES E. DECKER, *Secretary-Treasurer*
Norman, Oklahoma

RAYMOND C. MOORE, *Editor*
Lawrence, Kansas

PUBLICATIONS

The Association issues annually the "Bulletin of the American Association of Petroleum Geologists." Orders for the Bulletin should be addressed to the secretary, and drafts and money orders should be made payable to the Association. Volumes I, II and III are bound in cloth. Volume IV will be issued in parts, which will be distributed as completed.

Vol. I, 1917, 160 pages. Price	$3.00
Vol. II, 1918, 176 pages. Price	$3.00
Vol. III, 1919, 445 pages. Price	$5.00
Vol. IV, 1920, No. 1, 112 pages. Price	$2.00
Vol. IV, 1920, No. 2, 104 pages. Price	$2.00
Vol. IV, 1920, No. 3, 122 pages. Price	$2.00

DECLINE AND PRODUCTION OF THE RANGER FIELD

E. A. STEPHENSON AND H. R. BENNETT

The discovery of oil in Stephens and Eastland counties, Texas, in 1917, was heralded as a great boon to the oil industry, in that it appeared to offer some prospect of postponing for several years the inevitable decrease in the total yearly production of petroleum in the United States. The possible productive area appeared to be great, the drilling depths not prohibitive, the grade of oil high, and the initial production of the first wells was such as to warrant the belief that a large amount of oil would ultimately be obtained from each well.

In the case of the Ranger field—and the term is here used to include about eighty square miles close to Ranger and extending west and northwest to a point about seven miles north of Eastland—the history of the wells has been unique. Wells which had attractive initial productions have declined at an unusual rate, and many have been abandoned after producing only a few months, and most of them have become unproductive within less than a year. Operators who had invested most heavily in the field had great cause for alarm, because their original investment had been made with the expectation that Ranger would not be greatly different from other oil fields in the United States and elsewhere, and that after the flush production had passed, the wells would reach a settled condition with a much less rapid rate of decline, and would continue to produce commercial quantities of oil for many years.

As soon as the study was begun it became apparent that practically only wells which flow could be considered, as almost no data are available on pumping wells in Eastland county. The small amount of data which has been secured suggests no great recovery or lengthening of the life of the wells in the Ranger field proper by present methods of pumping.

PRODUCTION DECLINE OF WELLS

The decline of five representative Ranger wells is shown in Fig. 1.

By E. A. Stephenson, South Pennsylvania Oil Co., Pittsburgh, Pa.
H. R. Bennett., New Domain Co., Dallas, Texas.

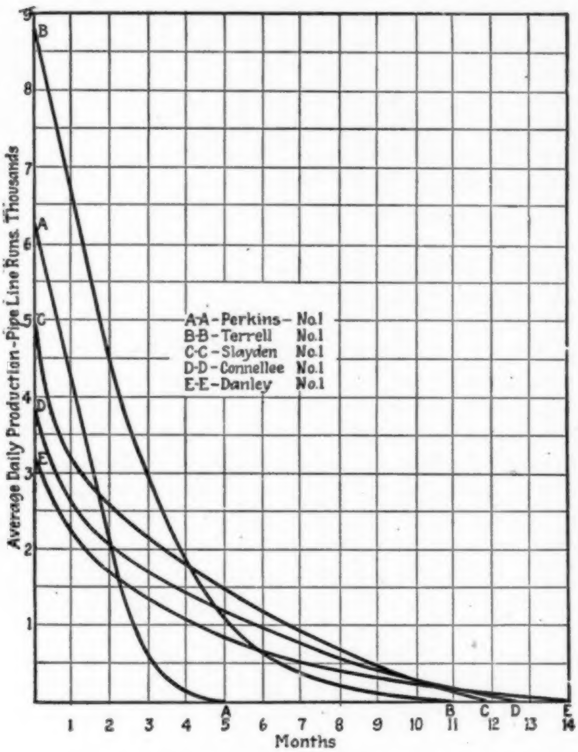


FIGURE 1. Typical decline curves for individual wells in the Ranger field.

The curves indicate a surprisingly rapid rate of decline, which is further indicated in the table, giving the percentage of oil produced during successive months by certain wells. The famous Perkins Well No. 1, which had an initial production of approximately 7,000 bbl. per day, beginning about the first of June, fell off in sixty days to 2,300 bbl. per day and in ninety days to 550 bbl. per day.

In five months from the date of its completion it was practically dead. The Emma Terrell No. 1, with an initial production of 9,000 bbl. per day, dropped in five months to 630 bbl. per day, and in eight months was without appreciable production. These declines are by no means unusual, and do not represent exceptional wells, but the life of Ranger wells is so short that one which produces a year is considered long-lived. The Colony School Lot No. 1, Perkins No. 1, and the W. E. Rock No. 2 produced practically all of their total oil during the first three months, as follows:

Average per cent per month for the three wells:

First month	43.1	
Second month	31.4	93.7
Third month	19.2	
Fourth month	4.4	6.2
Later period	1.8	

These three wells fall into a group of those which are typical of closely drilled territory and wells whose flush production is soon cut down by the completion of offsets.

The Emma Terrell No. 1 and the C. J. Keaghey B-1 are good examples of wells producing for about six months, even though some offset wells were drilled relatively close. The production of these two wells averages as follows:

Average per cent per month for the two wells:

First month	35.00		
Second month	25.00	77.1	
Third month	17.1		97.3
Fourth month	10.3		
Fifth month	6.3	20.2	
Sixth month	3.6		
Later period	2.6	2.6	

PERCENTAGE OF TOTAL OIL PRODUCED BY RANGER WELLS
DURING SUCCESSIVE MONTHS

Name of Well	1 Mo.	2 Mo.	3 Mo.	4 Mo.	5 Mo.	6 Mo.	7 Mo.
Colony School Lot	33.0	35.0	20.0	7.0	....	....	....
T. W. Connellee No. 1	23.0	16.8	14.9	11.2	9.5	8.0	....
B. A. Danley No. 1	27.0	16.7	13.3	10.9	9.4	7.0	4.5
S. V. Davis No.1	17.4	16.3	14.5	13.3	11.1	8.1	5.5
B. P Davenport No. 1	12.9	12.4	12.9	12.4	11.9	9.9	7.1
T. W. Duncan No. 1	11.0	10.0	11.0	11.0	11.0	11.0	11.0
T. W. Duncan No. 2	39.2	25.0	14.0	10.7	7.1	....	....
C. J. Keaghey B1	34.9	24.3	17.5	11.3	7.0	3.8	1.2
Merriman Church Lot No. 1	30.4	19.6	14.7	11.8	7.8	5.9	4.4
Eli Perkins No. 1	43.8	36.6	16.6	2.7	0.3	....	....
W. E. Rock No. 2	54.1	28.8	12.7	3.8	0.6	....	....
Ida Slayden No. 1	21.9	15.2	16.4	11.9	7.0	10.0	5.2
Emma Terrell No. 1	35.1	25.8	16.6	9.4	5.7	3.3	1.9

Name of Well	8 Mo.	9 Mo.	10 Mo.	11 Mo.	12 Mo.	13 Mo.	14 Mo.
Colony School Lot	....	....	....	....	....	....	....
T. W. Connellee No. 1	....	....	....	....	....	....	....
B. A. Danley No. 1	3.2	2.5	2.1	1.5	0.9	0.6	0.3
S. V. Davis No. 1	4.1	3.0	2.2	1.8	1.1	0.7	0.4
B. P. Davenport No. 1	5.7	4.3	3.3	2.6	1.9	....	....
T. W. Duncan No. 1	8.0	6.0	4.5	....	....	....	....
T. W. Duncan No. 2	....	....	....	....	....	....	....
C. J. Keaghey B1	....	....	....	....	....	....	....
Merriman Church Lot No. 1	2.9	2.0	0.5	....	....	....	....
Eli Perkins No. 1	....	....	....	....	....	....	....
W. E. Rock No. 2	....	....	....	....	....	....	....
Ida Slayden No. 1	4.0	4.0	2.9	2.1	1.4	1.0	0.2
Emma Terrell No. 1	1.2	0.6	0.2	0.1	....	....	....

The Ida Slayden No. 1, T. W. Connellee No. 1, Merriman Church Lot No. 1, B. A. Danley No. 1, and S. V. Davis No. 1 are good examples of wells which were the first ones drilled in their respective localities and were not soon affected by a great many offsets. Some of these wells had no offsets completed until they had been producing for about six months. The average production in terms of percentage is as follows:

Average per cent per month for five wells:

First month	23.7		
Second month	16.7	55.0	
Third month	14.6		
Fourth month	11.7		
Fifth month	9.7	28.4	95.1
Sixth month	7.0		
Seventh month	5.1		
Eighth month	3.8	11.7	
Ninth month	2.8		
Tenth month	2.6		
Eleventh month	1.4	4.4	
Twelfth month	1.0		

DISCUSSION OF INDIVIDUAL PROPERTIES

Lacking data for more individual wells[1] a series of appraisal curves, after Beal, has been prepared, showing the total production for the more important leases in the Ranger field, and estimates of the future production have been made in several instances. Serial numbers have been substituted for the names of the leases and the operating companies.

Property I, Fig. 3, 75 Acres—The lease designated Property I has been one of the most profitable in the entire field, and is a striking example of a successful drilling program. The first well was completed in November, 1918, as an 1,800-bbl. well, over a month before the first offset, and nearly every other well on the lease was completed in advance of its corresponding offset, the only exception

[1]The difficulty of obtaining data concerning production of individual wells during successive months is well known, and is due to the fact that the oil is generally run by leases instead of by single wells after the completion of the second well.

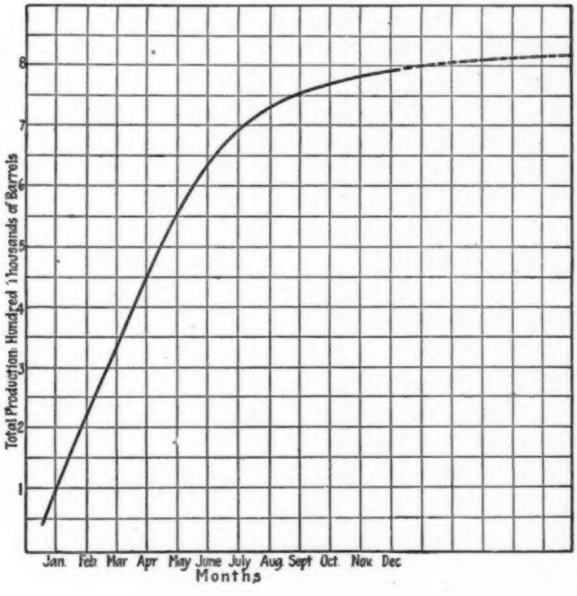


FIGURE 3. Total production of property I.

PROPERTY I (Fig. 3)

Year	Month	Production, Bbl.	Total to Date	No. Wells	Av. Bbl. per Well per Day
1919	Jan.	39,000	39,000	2	1,300
	Jan.	64,000	103,000	3	1,333
	Feb.	63,300	166,300	3	1,406
	Feb.	57,850	224,150	3	1,483
	Mar.	51,990	276,140	3	1,155
	Mar.	66,598	342,738	6	693
	Apr.	67,950	410,688	7	647
	Apr.	53,640	484,328	7	510
	May	42,400	506,728	9	311
	May	43,840	550,568	9	304
	June	40,500	591,068	9	300
	June	41,100	632,168	10	274
	July	39,000	671,168	10	200
	July	39,000	671,168	10	200
	July	21,920	693,088	11	124
	Aug.	18,000	711,088	12	100
	Aug.	16,688	727,776	12	87
	Sept.	14,400	742,176	12	80
	Sept.	11,085	753,261	12	63
	Oct.	7,950	761,211	12	44
	Oct.	7,680	768,891	12	40
	Nov.	4,200	773,091	12	23
	Nov.	4,500	777,591	12	25
	Dec.	7,500	785,091	12	42
	Dec.	6,080	791,171	12	32

Estimated future production about 25,000 bbl.

being an offset at the northwest corner, which was completed about a month before No. 3 of Property I. Further, the initial production of each well, with the exception of the one just noted, was greater than that of its offset. At that the tract has been over-drilled, and it is certain that three wells in the center of the tract will not pay, and should not have been drilled. The total yield per acre has been about 12,000 bbl. and the tract east of Property I has yielded only 1,700 bbl. per acre, and the tract on the west but 2,100 bbl. per acre.

Property II, Fig. 4, 75 Acres—The curve for Property II must be drawn in two segments, one for Wells Nos. 1 and 2, and the other, or upper curve, for Wells Nos. 3 to 8. Wells Nos. 1 and 2 are at the south side of the tract, and both came in at about 1,200 bbl. as though they would be good wells, but fell off rapidly because they had been preceded by an offset on the west side, which had been completed two months earlier at 1,800 bbl. initial, and had already produced about 60,000 bbl. The combined yield of Nos. 1 and 2, Property II, had reached 62,000 bbl. when No. 4 came in, but the

continuation of the lower curve shows that these had already produced nearly all of their total oil, with only 6,000 bbl. estimated future production, or a total of 34,000 bbl. per well.

Wells Nos. 3 and 4, at the north end of the tract, had been preceded by 4,000- and 5,000-bbl. offset wells to the north, and their combined initial production was less than 325 bbl. per day. With a total production from the lease up to January 1, of 127,461 bbl., plus an estimated future production of 10,000 bbl., it is impossible that the lease could be profitable. The property might have been profitable if it had been abandoned the last of April without drilling additional wells. The yield per acre was 1,700 bbl.

PROPERTY II (Fig. 4)

Year	Month	Production, Bbl.	Total to Date	No. Wells	Ave. Bbl. per Well per Day
1918	Dec.	10,500	10,500	1	1,500
1919	Jan.	30,600	41,100	2	500
	Feb.	11,980	52,080	2	210
	Mar.	7,890	59,970	2	132
	Apr.	2,776	62,746	2	45
	May	9,435	72,141	4	64
	June	16,095	88,236	6	90
	July	11,520	99,756	6	62
	Aug.	10,397	110,152	7	48
	Sept.	4,665	114,818	7	22
	Oct.	3,443	118,261	7	16
	Nov.	6,405	124,666	8	27
	Dec.	2,795	127,461	8	11

Estimated future production about 10,000 bbl.

Property III, Fig. 5, 220 Acres—On the Property III lease, No. 1 well produced nearly 400,000 bbl. before the No. 2 was completed, and about 200,000 bbl. before any offset came in. The 400,000 bbl. was produced during a period of five months, but by the end of that time the rate of decline for the entire lease was established, and, taking the later wells as a group, they have not paid, though there is a possibility that certain ones have been profitable. The figures for production, converted into dollars, may be stated roughly as follows:

	Barrels:	
Production well No. 1	422,000	
Royalty	52,750	
Net barrels	369,250 @ $2.25 per bbl.	$832,000
Costs of well		40,000
Profit		$792,000

There are in all twelve other producers, ranging from 20 to 1,200 bbl. initial production, and all combined giving an initial production of 3,600 bbl. One rig was skidded and drilled again, and there are three dry holes, making a total of seventeen wells, which produced 60,000 bbl. The profit estimate follows:

	Barrels:	
Total oil from 17 wells	60,000	
Royalty	7,500	
Net barrels	52,500 @ $2.50 per bbl	$131,250
Cost of 17 wells @ $40,000		680,000
Loss on later wells		548,750
Profit on first well	$792,000	
Loss on later wells	548,750	
Net profit	$243,250	

Roughly stated, the operators lost $550,000 by drilling the later wells on the lease. The wells on the tracts adjoining this lease were completed at an average time of 2⅜ months ahead of the Property III wells, and had a total initial production of 13,650 bbl., or 846 bbl. per well for sixteen wells, as compared with 2,980 bbl.

PROPERTY III (Fig. 5)

Year	Month	Production, Bbl.	Total to Date	No. Wells	Ave. Bbl. per Well per Day
1918	Dec.	60,335	60,335	1	6,033
1919	Jan.	145,042	205,377	1	4,634
	Feb.	85,232	290,609	1	2,841
	Mar.	58,575	349,184	1	1,952
	Apr.	30,683	379,867	1	1,023
	May	18,717	398,638	1	628
	June	21,894	420,532	2.2	331
	July	10,100	430,632	4	84
	Aug.	6,922	437,554	6	38
	Sept.	11,825	449,379	10	39
	Oct.	7,249	456,628	10	24
	Nov.	6,365	462,993	11	19
	Dec.	4,655	467,648	11.6	13

Estimated future production about 15,000 bbl.

initial production for the Property III wells, or an average of 248 bbl. per well for twelve wells. The advantage which first wells have is thus seen to be tremendously greater than is noted in any other field. It is doubtful if any method of pumping will ever obtain enough oil to pay back the losses on this lease, due to the tardy drilling program and the excessive number of wells. The yield per acre was 2,100 bbl.

Property IV, Fig. 6, 146 Acres—The curve for Property IV indicates a normal rate of development and completion. On an average, the eleven wells were completed one month ahead of their offsets, but the largest two wells were three to six months ahead of their offsets, and

PROPERTY IV (Fig. 6)

Year	Month	Production, Bbl.	Total to Date	No. Wells	Ave. Bbl. per Well per Day
1919	Apr.	6,675	6,675	1	445
	Apr.	75,000	81,675	2	1,866
	May	233,535	315,210	4	1,929
	June	183,081	498,291	4	1,744
	July	110,368	608,659	5	675
	Aug.	88,092	696,751	5	587
	Sept.	80,734	777,485	6	280
	Oct.	35,706	813,191	6	192
	Nov.	44,564	847,755	6	172
	Dec.	23,359	871,114	8	163

the bulk of the oil from the tract, or about 700,000 bbl., was produced by three large wells in the southwest corner of the lease. The one dry hole and the six smaller wells have been a financial loss, and more profit would have been made by drilling four or five properly spaced wells and then abandoning the property. The yield per acre was about 6,000 bbl. The future production is not readily estimated, owing to the complexity of the curve and the uncertainty as to its extension, but it is probably less than 75,000 bbl. and more than 50,000 bbl. In such cases the daily runs make it possible to plot a more satisfactory and accurate curve for estimating future production.

Property V, Fig. 7, 160 Acres—Well No. 1, on Property V, made 3,800 bbl. initial production, and has made a total production of 421,000 bbl. Its three offsets had a combined initial production of only 510 bbl. The six other producers on the tract had a total initial production of 3,800 bbl., and with the estimates of future

production will probably yield 124,000 bbl., or an average of 20,660 bbl. per well. The offsets to these six wells on Property V were completed at an average time of two and three-quarters months ahead of the Property V wells, and had a combined initial production of 9,500 bbl., or 5,700 bbl. better than the Property V wells. One dry hole was also drilled on this lease.

PROPERTY V (Fig. 7)

Year	Month	Production, Bbl.	Total to Date	No. Wells	Ave. Bbl. per Well per Day
1918	July	40,512	40,512	1	3,800
	Aug.	74,326	114,838	1	2,400
	Sept.	63,529	178,367	1	2,117
	Oct.	49,544	227,911	1	1,651
	Nov.	53,046	280,957	1	1,768
	Dec.	36,062	317,019	1	1,202
1919	Jan.	48,281	365,300	1.5	1,070
	Feb.	17,284	382,584	2	300
	Mar.	46,202	482,786	3	519
	Apr.	37,806	466,786	4	315
	May	31,032	497,624	4	258
	June	23,157	510,781	5	154
	July	13,280	524,060	7	63
	Aug.	4,889	528,949	7	23
	Sept.	1,473	530,422	7	7
	Oct.	No runs	....	....	....
	Nov.	No runs	....	....	....
	Dec.	437	530,859	7	1

Approximately estimated, the financial summary is as follows:

	Barrels:		
Production well No. 1	421,000		
Royalty	52,625		
Net barrels	368,375	@ $2.25 per bbl.	$828,688
Costs of well			40,000
Net profit on No. 1 well			$788,688

Production of six other wells and one dry hole as follows:

	Barrels:		
Total production	124,000		
Royalty	15,500		
Net barrels	108,500	@ $2.25 per bbl.	$244,125
Cost of 7 wells			280,000
Loss			$ 35,875
Net profit on lease			$752,813

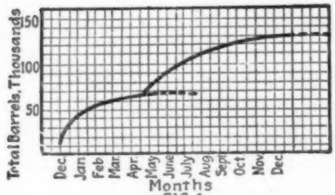


FIG. 4

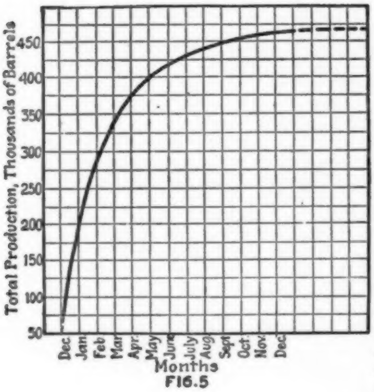


FIG.5

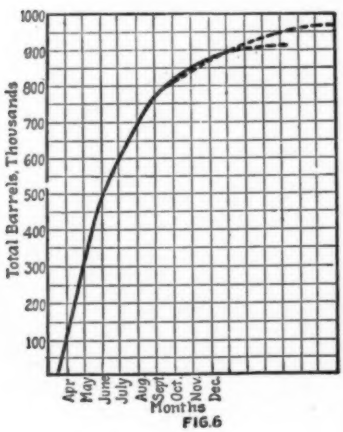


FIG.6

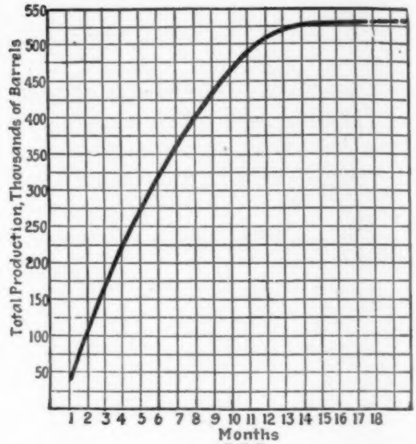


FIG.7

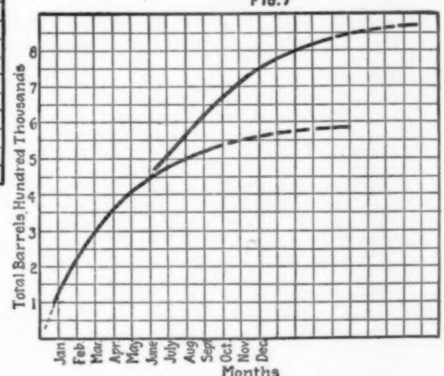


FIG.8

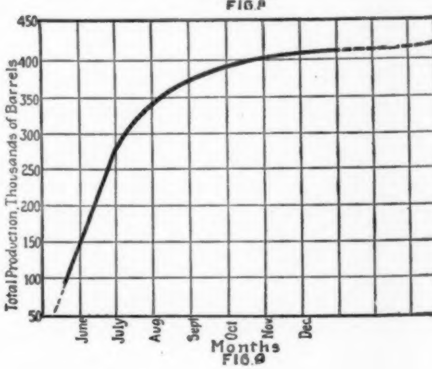


FIG.9

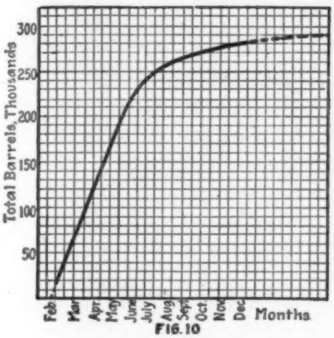


FIG. 10

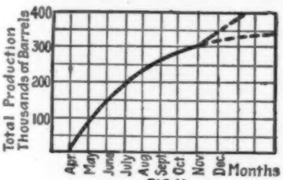


FIG. 11

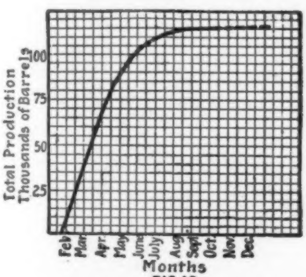


FIG. 12

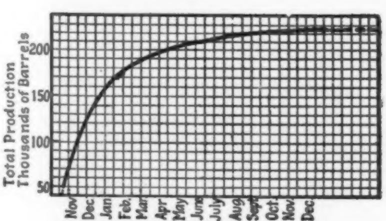


FIG. 13

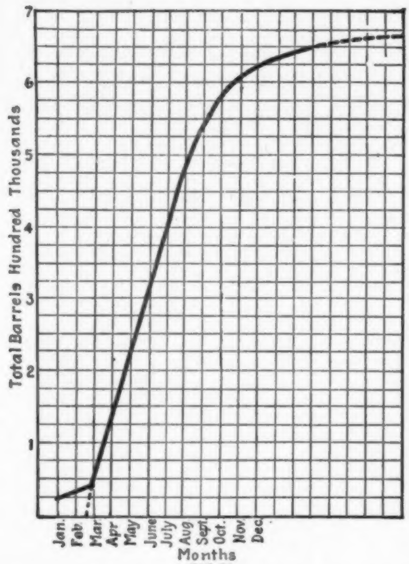


FIG. 14

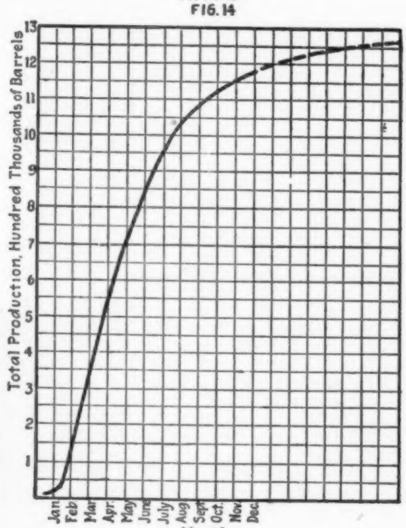


FIG. 15

It is clear that some of the six later wells have made little profit and the property could also have been abandoned with but one well on it and left a handsome profit. It is also doubtful if improved methods of recovery will ultimately bring as much profit as would have been secured if an intelligent drilling program had been followed. The yield per acre was 3,400 bbl.

PROPERTY VI (Fig. 8)

Year	Month	Production, Bbl.	Total to Date	No. Wells	Ave. Bbl. per Well per Day
1919	Jan.	73,800	73,800	1	4,920
	Jan.	49,500	123,300	1	3,300
	Feb.	46,800	170,000	1	3,120
	Feb.	42,975	213,075	1	2,865
	Mar.	40,000	253,075	1	2,700
	Mar.	39,840	292,915	1	2,656
	Apr.	32,025	324,940	1	2,135
	Apr.	28,560	353,500	1	1,905
	May	27,480	380,980	1	1,832
	May	21,600	402,580	1	1,440
	June	21,600	424,180	1	1,440
	June	21,000	445,180	1	1,400
	July	22,500	467,680	2	750
	July	19,840	487,520	3	450
	Aug.	30,150	517,670	4	502
	Aug.	34,692	552,362	4	543
	Sept.	18,250	570,612	4	304
	Sept.	24,450	595,062	5	326
	Oct.	38,352	633,414	6	399
	Oct.	28,500	661,914	7	271
	Nov.	30,300	692,204	7	289
	Nov.	23,800	716,024	9	169
	Dec. / Dec.	34,418	750,482	11	113 / 108

Property VI, Fig. 8, 254 Acres—The first well on Property VI, in the northeast corner of the tract, was completed with an initial production of 5,000 bbl., and had produced 450,000 bbl. before any other wells on the lease came in and before any offset well was completed. The initial production of the eighteen other wells on the lease was 7,800 bbl., an average of 433 bbl. each. The initial production of the three offsets to No. 1 totaled, 3,300 bbl., or 1,100 bbl. each; the offsets to all the other Property VI wells made 12,000 bbl. total initial, but there are many wells not yet completed. The entire future production is about 150,000 bbl., which will make the total production for the entire lease about 900,000 bbl. Eleven wells are completed and ten more drilling, most of which should not be

continued.[2] A better method of spacing the wells, with a satisfactory arrangement in respect to offsets, would have made it possible for about ten wells to obtain all of the oil from the property. The yield per acre was 3,800 bbl.

PROPERTY VII (FIG. 9)

Year	Month	Production, Bbl.	Total to Date	No. Wells	Ave. Bbl. per Well per Day
1919	June	94,500	94,500	1	6,300
	June	61,755	156,255	1	4,117
	July	83,430	239,685	1	5,562
	July	46,464	286.149	1	2,904
	Aug.	34,680	320,829	1	2,312
	Aug.	24,320	345,149	1	1,520
	Sept.	8,325	353,474	1	555
	Sept.	12,750	366,224	2	425
	Oct.	17,175	383,399	2	572
	Oct.	12,480	395,879	2	415
	Nov.	3,945	399,824	3	132
	Nov.	5,595	405,419	3	125
	Dec.	7,560	412,979	4	126

Estimated future production 13,000 bbl.

Property VII, Fig. 9, 40 Acres—The Well No. 1, on Property VII, completed on June 6, 1919, as a 7,000-bbl. well, marked the further extension of the Ranger field. Before any offset wells had been brought in, this well produced 300,000 bbl. out of a total production of 375,000 bbl. The first offset was only 100 feet away, however, and after it came in the big well on Property VII declined rapidly, a decline which was augmented by many other close-in wells. Three other wells on Property VII will not pay, and a fourth operation has recently been abandoned before reaching the "black lime." The best financial procedure would have been to abandon the property in September, 1919.

After Well No. 1 had produced about 150,000 bbl., the tract, forty acres, was sold for a reported consideration of $1,000,000. As the production after the transfer cannot run over 275,000 bbl., equivalent to about $600,000, from which must be subtracted the cost of four additional wells, it is difficult to understand how the purchasers can overcome the certain loss of more than $500,000, unless they can sell out to a buyer as unfamiliar with the rate of

[2]A 25-bbl. completion on this lease has been reported since the preparation of this paper.

decline at Ranger as they were at the time the transaction was made. The yield was about 10,000 bbl.

PROPERTY VIII (Fig. 10)

Year	Month	Production, Bbl.	Total to Date	No. Wells	Ave. Bbl. per Well per Day
1919	Feb.	18,900	18,900	1	1,260
	Mar.	46,956	65,856	1	1,516
	Apr.	50,040	119,896	1	1,668
	May	52,600	172,498	1	1,700
	June	44,415	216,911	1	1,480
	July	29,636	246,547	1	956
	Aug.	11,980	257,527	2	193
	Sept.	9,150	266,677	2	152
	Oct.	4,996	271,673	3	58
	Nov.	6,345	278,018	3	70
	Dec.	2,915	280,933	3	31

Estimated future production not over 8,000 bbl.

Property VIII, Fig. 10, 110 Acres—The curve for Property VIII is one of the most striking of the entire field. Well No. 1 had produced 240,000 bbl. out of a total estimated production of about 300,000 bbl., before any offset well had been completed, but in July the offset well on the south was completed as a 3,800-bbl. well and the No. 1 Property VIII was ruined. The entire production on this lease since the completion of the 3,800-bbl. offset has been only 15,000 bbl. The yield per acre was 2,700 bbl.

Property IX, Fig. 11, 140 Acres—The first well on Property IX had produced about 300,000 bbl. before any offset was completed near it. The recent completion of Well No. 3 at the southwest corner of the tract would suggest that these are the only wells which can profitably be drilled on the lease. It should be noted that the

PROPERTY IX (Fig. 11)

Year	Month	Production, Bbl.	Total to Date	No. Wells	Ave. Bbl. per Well per Day
1919	Feb.	25	....	....	....
	Mar.	55	80	....	....
	Apr.	13,040	13,040	1	1,800
	May	83,031	96,071	1	2,771
	June	52,758	148,829	1	1,793
	July	45,926	194,755	1	1,530
	Aug.	41,254	235,809	1	1,330
	Sept.	31,474	267,283	1	1,049
	Oct.	19,005	286,288	1	613
	Nov.	18,637	304,925	1	602
	Dec.	30,306	335,431	2	505

curve for Well No. 1 is definitely established, and the total future production for the well can be readily estimated as about 25,000 bbl. The curve for Well No. 2 is plotted separately. A rough estimate of the future production of Well No. 2 may be made by comparing the curves of other similar properties. The yield per acre was about 2,500 bbl.

PROPERTY X (Fig. 12)

Year	Month	Production, Bbl.	Total to Date	No. Wells	Ave. Bbl. per Well per Day
1919	Feb.	737	737	1	150
	Mar.	31,733	32,470	1	725
	Apr.	30,192	62,662	2	522
	May	23,036	85,698	2	381
	June	15,123	100,821	2	310
	July	7,898	108,719	2	116
	Aug.	3,948	112,667	2	64
	Sept.	1,073	113,730	2	17
	Oct.	310	114,040	2	5
	Nov.	630	114,670	2	10

Estimated future production about 3,000 bbl.

Property X, Fig. 12, 160 Acres—Property X is a good example of one which is practically exhausted, having produced 93 per cent of its total oil during the first six months of its life. After August, 1919, the curve is nearly flat. The production per acre has been 750 bbl.

PROPERTY XI (Fig. 13)

Year	Month	Production, Bbl.	Total to Date	No. Wells	Ave. Bbl. per Well per Day
1918	Nov.	61,350	61,350	1	2,045
	Dec.	43,865	105,215	1	1,415
1919	Jan.	56,850	162,065	2	917
	Feb.	19,410	181,475	2	693
	Mar.	12,417	193,892	3	131
	Apr.	5,520	199,412	4	46
	May	3,148	202,560	4	25
	June	2,700	205,260	5.5	20
	July	5,639	210,899	6	29
	Aug.	3,652	214,551	7	18
	Sept.	4,530	219,081	8	19
	Oct.	1,828	220,909	8	7
	Nov.	1,395	222,304	8	5
	Dec.	1,230	223,534	9	4

Property XI, Fig. 13, 317 Acres—The Property XI lease has produced a total of 223,000 bbl., and its estimated future production is less than 5,000 bbl. Half of this oil came from Well No. 1, and the

first three wells drilled are the only ones which have been profitable. Over 200,000 bbl. has been produced from the three wells. The six other wells have all been small producers, but too small to pay their drilling costs. If this property had been abandoned in March, 1919, it could have shown a profit, but because of excessive drilling it has just about broken even. The yield per acre was about 620 bbl.

PROPERTY XII (Fig. 14)

Year	Month	Production, Bbl.	Total to Date	No. Wells	Ave. Bbl. per Well per Day
1919	Jan.	19,280	19,280	1	625
	Feb.	12,550	31,830	1	445
	Mar.	10,055	41,885	1	325
	Apr.	95,640	137,525	2	1,296
	May	64,050	201,575	3	1,380
	June	91,065	292,640	4	819
	July	105,204	397,844	5	528
	Aug.	74,310	472,154	5	481
	Sept.	38,565	510,719	6	236
	Oct.	31,438	582,155	7	158
	Nov.	23,550	605,705	7	103
	Dec.	19,500	623,205	7	93

Property XII, Fig. 14, 200 Acres—The wells on Property XII have yielded 625,000 bbl., and should yield between 40,000 and 50,000 bbl. more, making the total production approximately 675,000 bbl. Seven wells have been completed on the lease, and there are eleven more locations or drilling wells, at least ten of which should never be drilled. The drilling program has been successful, and almost every well on the lease has preceded its offset by from three to eight months. The yield per acre was 3,500 bbl.

PROPERTY XIII (Fig. 15)

Year	Month	Production, Bbl.	Total to Date	No. Wells	Ave. Bbl. per Well per Day
1919	Jan.	8,535	8,535	1	569
	Jan.	6,400	14,935	1	400
	Feb.	16,050	30,985	2	535
	Feb.	58,825	89,810	3	1,510
	Mar.	112,800	202,610	5	1,505
	Mar.	153,600	356,210	6	1,600
	Apr.	111,450	467,750	6	1,240
	Apr.	88,770	556,430	6	986
	May	85,380	641,810	7	813
	May	60,800	702,610	7	543
	June	50,265	752,875	7	480
	June	87,255	840,130	11	492
	July	48,000	888,130	11	291

PROPERTY XIII (Fig. 15)

Year	Month	Production, Bbl.	Total to Date	No. Wells	Ave. Bbl. per Well per Day
	July	86,582	974,712	12	451
	Aug.	38,985	1,013,697	13	200
	Aug.	37,296	1,050,993	13	180
	Sept.	26,835	1,077,828	14	127
	Sept.	20,955	1,098,783	14	99
	Oct.	14,265	1,113,048	14	68
	Oct.	20,400	1,133,448	15	85
	Nov.	16,125	1,149,503	15	72
	Nov.	15,370	1,164,873	16	63
	Dec.	13,513	1,178,386	16	56
	Dec.	11,625	1,196,011	16	48

Estimated future production about 100,000 bbl.

Property XIII, Fig. 15, 500 Acres—The curve for Property XIII is similar to the curves for Property I and Property XII, and indicates a vigorous and successful drilling program, though about twice as many wells have been drilled as was necessary, if the wells now under way are considered. It is doubtful if the wells still drilling can prevent the decline indicated by the curve. The estimates of future production suggests that not many more wells can be drilled profitably. The yield per acre is 2,600 bbl.

PROPERTY XIV. (Fig. 16)

Year	Month	Production, Bbl.	Total to Date	No. Wells	Ave. Bbl. per Well per Day
1918	June	10,844	10,844	1	361
	July	11,366	22,210	1	366
	Aug.	12,416	34,626	1	400
	Sept.	11,596	46,222	1	386
	Oct	9,520	55,742	1	307
	Nov.	9,212	64,954	1	307
	Dec.	10,980	75,934	1	354
1919	Jan.	8,392	84,324	1	270
	Feb.	5,626	89,950	1	201
	Mar.	4,604	94,554	1	145
	Apr.	27,523	122,077	2	459
	May	18,044	140,121	2	291
	June	9,944	150,065	2	166
	July	8,238	158,303	2	133
	Aug.	5,722	164,025	2	92
	Sept., Oct., Nov., no runs.				
	Dec.	2,562	166,587	3	8

Property XIV, Fig. 16, 160 Acres—Property XIV was one of the first leases drilled in the field. The curve cannot be plotted readily as a continuous one, but if broken in two parts it represents the

production of the first and second wells, and also makes it possible to estimate the probable future production of each. The first well produced about 110,000 bbl. and the second, 55,000 bbl. The third well is dry, but is well placed, and should have been drilled. The property has paid, but no further drilling should be done. The yield per acre was about 1,060 bbl.

PROPERTY XV (Fig. 17)

Year	Month	Production, Bbl.	Total to Date	No. Wells	Ave. Bbl. per Well per Day
1918	July	36,780	36,780	1	1,226
	Aug.	34,260	71,040	1	1,142
	Sept.	22,020	93,060	1	734
	Oct.	25,020	118,080	1	835
	Nov.	36,000	154,080	2	825
	Dec.	55,500	209,580	2	925
1919	Jan.	34,892	244,472	2.5	458
	Feb.	28,132	272,604	4	248
	Mar.	17,925	290,604	4	145
	Apr.	24,110	314,639	5	167
	May	22,167	336,806	8.5	85
	June	16,969	353,771	9	63
	July	12,325	366,096	9	44
	Aug.	11,527	377,623	9	41
	Sept.	6,240	383,863	9	23
	Oct.	5,818	389,681	9	20.5
	Nov.	7,920	397,601	9	29
	Dec.	6,562	404,163	9	23.5

Estimated future production about 25,000 bbl.

Property XV, Fig. 17, 120 Acres—Well No. 1 on Property XV was the first well completed in this general locality, preceding all others by about three months, and producing over 100,000 bbl., or about one-fourth the production from the entire lease, before the offset wells were completed. The second well in the locality, the offset on the west, had an initial production of 1,800 bbl. The two wells have produced practically all of the oil in the vicinity. The second well on Property XV, at the extreme north edge of the tract, was well placed, and came in at about the same time as its offset. Both No. 2 and its offset proved to be good wells, but it is doubtful if any of the other wells near them have paid. Wells Nos. 1 and 2 produced the bulk of oil for the lease, and it is questionable if any of the other eight wells on Property XV have been profitable. The drilling of wells in the northwest part of the farm was especially unprofitable, as an 1,800-bbl. well just over the line on the adjoining

lease had been completed at an earlier date. The yield per acre was 3,500 bbl.

PROPERTY XVI (Fig. 18)

Year	Month	Production, Bbl.	Total to Date	No. Wells	Ave. Bbl. per Well per Day
1918	Aug.	4,476	4,476	1	148
	Sept.	4,587	9,063	1	153
	Oct.	3,516	12,579	1	117
	Nov.	4,382	16,971	1	146
	Dec.	1,917	18,888	1	63
1919	Jan.	12,483	31,371	1	416
	Feb.*	65,504	96,875	2	1,091
	Mar.	60,876	157,751	2	1,014
	Apr.	35,827	183,578	2	697
	May	26,249	209,828	2	437
	June	24,392	244,220	3	271
	July	22,841	257,061	3	253
	Aug.	15,076	282,137	3	167
	Sept.	15,057	297,194	3	166
	Oct.	6,762	303,956	3	75
	Nov.	17,590	321,546	4	146
	Dec.	14,055	335,611	4	117

Estimated future production about 50,000 bbl.

Property XVI, Fig. 18, 220 Acres—The curve for Property XVI resembles closely that of Property XV, and in both cases the drilling program has been tardy. If the same number of wells had been completed at more nearly the same time, that is, had there been conducted a speedier drilling campaign, more oil would have been

PROPERTY XVII (Fig. 19)

Year	Month	Production, Bbl.	Total to Date	No. Wells	Ave. Bbl. per Well per Day
1918	Mar.	11,424	11,424	1	....
	Apr.	26,989	38,413	1	899
	May	26,586	64,999	1	858
	June	26,316	91,315	1	877
	July	26,516	117,831	1	856
	Aug.	23,550	141,381	1	760
	Sept.	16,416	157,797	1	547
	Oct.	13,592	171,389	1	438
	Nov.	10,576	181,965	1	352
	Dec.	28,384	210,349	2	458
1919	Jan	40,698	251,047	3	438
	Feb.	16,808	267,815	3	200
	Mar.	12,006	279,821	3	129
	Apr.	9,748	289,569	3	108
	May	5,790	295,359	3	62
	June	4,282	299,641	3	47
	July	3,504	303,145	3	38
	Aug.	1,082	304,221	3	12
	Sept.	No runs	....	3	....
	Oct.	672	304,899	3	4

produced. Most of the oil was produced by wells No. 2 and No. 5, though two of the other wells have probably paid. The yield per acre was 1,740 bbl.

Property XVII, Fig. 19, 80 Acres—Property XVII has three producers and one dry hole, and a total production of about 310,000 bbl., two-thirds of which came from the first well before any offsets had been completed. The first and second wells together have produced almost all of the oil from this general locality, or a tract of about 200 acres. The yield per acre was 3,600 bbl.

Property XVIII, Fig. 20, 450 Acres—The curve for this property tells a complete story, for the lease has shown no runs since October, 1919. The important wells were all in the northwest part of a 450-acre tract. Wells in other parts of the lease have been so small as

PROPERTY XVIII (Fig. 20)

Year	Month	Production, Bbl.	Total to Date	No. Wells	Ave. Bbl. per Well per Day
1918	July	77,676	....	1	2,580
	Aug.	126,670	204,346	3	1,407
	Sept.	160,862	365,208	4	1,346
	Oct.	118,060	483,268	4	983
	Nov.	131,097	614,365	5	878
	Dec.	158,956	773,321	7	773
1919	Jan.	127,597	900,918	8	531
	Feb.	78,689	979,607	8	328
	Mar.	77,714	1,057,321	9	237
	Apr.	44,406	1,101,727	9	164
	May	19,209	1,120,936	9	71
	June	10,462	1,131,398	9	38
	July	6,700	1,138,098	11	22
	Aug.	1,202	1,139,300	11	3.6
	Sept.	2,730	1,142,030	16	6
	Oct.	No runs	....	....	....
	Nov.	No runs	....	....	....
	Dec.	No runs	....	....	....

Total wells drilled, 18.

to suggest most of the oil from the entire lease has been obtained. There has been some over-drilling due to the necessity of offsetting. The curve resembles those of Properties V, XII and XIII. The yield per acre was 2,640 bbl.

Property XIX, Fig. 21, 750 Acres—The curve for Property XIX is almost a one-well curve, as one well had produced over a million barrels, out of a total production for the lease, up to January 1, 1920, of 1,350,000 bbl. About 200 acres of the lease may be considered as nearly virgin territory, so that the estimate of future production,

PROPERTY XIX (Fig. 21)

Year	Month	Production, Bbl.	Total to Date	No. Wells	Ave. Bbl. per Well per Day
1919	Feb.	51,048	51,048	1	....
	Mar.	75,020	126,068	1	5,668
	Mar.	99,144	225,212	1	6,184
	Apr.	97,500	322,712	1	6,500
	Apr.	94,500	417,212	1	6,300
	May	78,150	495,362	1	5,210
	May	83,200	578,562	1	5,200
	June	78,000	656,562	1	5,200
	June	71,700	727,262	1	4,780
	July	64,770	792,032	1	4,318
	July	61,216	853,248	1	3,826
	Aug.	56,775	910,023	1	3,785
	Aug.	34,016	944,039	1	2,126
	Sept.	45,930	989,969	2	1,531
	Sept.	40,380	1,030,349	2	1,346
	Oct.	73,408	1,103,757	4	571
	Nov.	75,569	1,179,326	6.5	494
	Dec.	128,033	1,337,359	8.5	457

900,000 bbl., is tentative. From the drilling program, which is now under way, there are twenty-two wells drilling, and the character of operations on adjoining leases indicates that the tract is to be over-drilled. The yield per acre up to date has been about 3,000 bbl.

PROPERTY XX (Fig. 22)

Year	Month	Production, Bbl.	Total to Date	No. Wells	Ave. Bbl. per Well per Day
1919	Apr.	6,750	6,750	1	450
	May	12,540	19,290	1	836
	May	17,280	36,570	1	1,080
	June	16,500	53,070	1	1,100
	June	19,515	72,585	1	1,301
	July	17,250	89,835	1	1,150
	July	6,976	86,811	1	436
	Aug.	4,770	101,581	1	318
	Aug.	3,120	104,701	1	195
	Sept.	4,920	109,621	1	328
	Sept. No runs	....	....	....	....
	Oct.	480	110,101	1	32
	Oct.	192	110,293	1	12

Property XX, Fig. 22, School Lot—Property XX furnishes a good example of the amount of oil which can be obtained from a small tract by a first well. The single well on this tract was completed nearly two months before any offset, and four to five months before more than one offset well had been drilled. The total production from the well was 110,000 bbl.

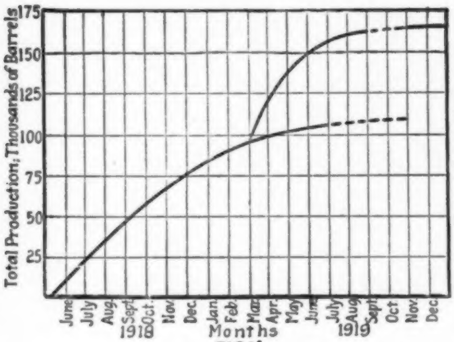


FIG. 16

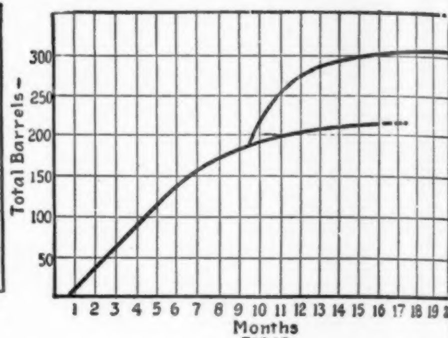


FIG. 19

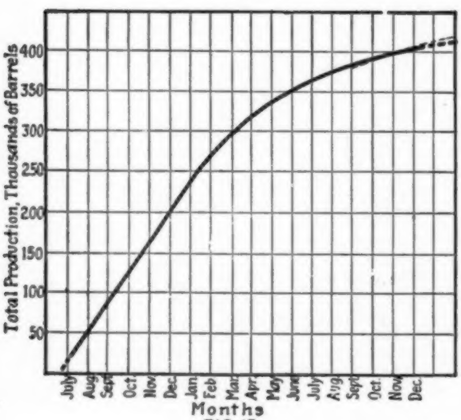


FIG. 17

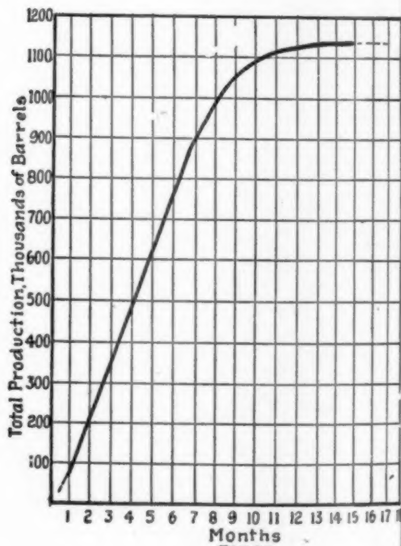


FIG. 20

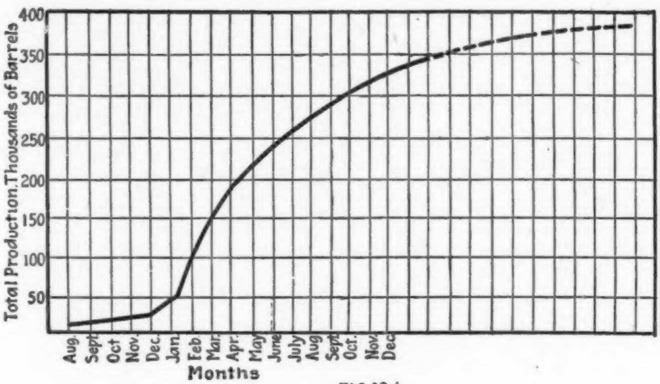


FIG 18

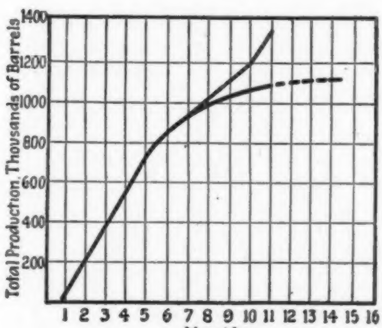


FIG.21

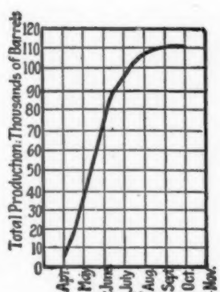


FIG.22

Table I, based on the actual runs, plus the estimates of future production, shows the relation between the amount of oil produced by a No. 1 well during its first month and the total amount of oil produced by the same well.

TABLE I.

	Production First Month	*Total Oil From Well, Barrels*
Property III	165,000	415,000
Property V	70,000	400,000
Property VI	123,000	530,000
Property VII	156,000	375,000
Property X	92,000	340,000
Property XI	61,000	110,000
Property XIII	45,000	260,000
Property XIV	11,000	100,000
Property XVII	27,000	210,000
Property XIX	350,000	1,200,000
Property XX	55,000	110,000

The foregoing figures of Table I point to the conclusion that a Ranger well produces about 33 per cent of its total oil during the first month of its life, a conclusion which receives additional warrant from the fact that these are representative wells.

RELATION OF PRODUCTION OF FIRST WELL TO TOTAL OIL FROM THE LEASE

The curves and production figures given show clearly that the

TABLE II.

Per cent of total production obtained from first well:

	Total Oil from lease Barrels	*No. Acres*	*Oil Produced by first well Barrels*	*Per Cent by first Well*
Property III	480,000	220	422,000	88
Property V	540,000	160	421,000	78
Property VI	900,000	254	585,000	65
Property VII	425,000	40	375,000	88
Property VIII	300,000	110	260,000	86
Property IX	500,000	140	300,000	60
Property XI	228,000	317	110,000	48
Property XV	425,000	120	160,000	38
Property XVII	310,000	80	215,000	69
Property XIX	2,225,000	750	1,200,000	58

greater part of the oil from most of the properties is produced by the first well completed. These data are tabulated in Table II, but it is recognized that the figures are not altogether comparable, owing to the great differences in the sizes of the tracts and the variations in the nature of the drilling programs.

An average of the percentages given above must not be taken too literally, but it appears that first wells produce approximately 75 per cent of the total oil from the leases.

CONCLUSION

1. The rate of decline of the Ranger wells is precipitous. Wells completed with initial productions of from two to ten thousand barrels per day fall off so rapidly that most of them cease to produce within less than a year.

2. The amount of oil produced by a No. 1 well during the first thirty days after completion is, on the average, about 33 per cent of the total oil which such a well will ultimately produce. In the properties examined in this paper this amount varies from 11 per cent to 35 per cent. The wells with the smaller percentages have commonly made large volumes of gas.

3. In proved territory the first well on the lease produces an enormous portion of the total oil from the lease. The percentage is greatest for the very large wells, and ranges from 38 to 88.

4. The initial production of offset wells is commonly much less than that of first wells, their rate of decline is more rapid, and their total production much smaller. This is seen especially in the case of the offsets to Property I, and similar offsets to Properties V, VI, and III, and is also shown by the relatively small per cent of oil produced on these and other leases by the wells which were later than No. 1. This makes it clear that in many cases it would have been more profitable for the operators not to have drilled offset wells, especially if such offsets were not started until after the first well was completed.

5. Either the oil drains into the wells from a great distance or else the decline in gas pressure is so great that it quickly becomes too weak to force out the oil. As the producing stratum is commonly a very fine-grained rock, which is also exceedingly hard, the latter is probably the case, and, if so, the per cent of recovery is extremely

low and a large amount of oil is undoubtedly left in the ground. This would suggest that Ranger offers a great opportunity for the development of more efficient methods of recovery than are now in use.

6. Leases in the Ranger field could have been drilled with far greater profit if the operating companies had recognized early in the development the necessity of drilling agreements to prevent close spacing of wells. Though this is a post-mortem statement as regards much of the field, such arrangements can still be made to control the drilling of undeveloped parts of the "black-lime" producing areas. If drilling agreements are made, the chances of profit on future operations will be greatly increased.

7. Calculations of the yield per acre for the entire field depend upon the somewhat arbitrary decision as to how large an area should be included. For a group of thirty of the more important properties, with a combined area of 6,500 acres, the yield up to March 1, was about 2,200 bbl. per acre, with a probable future production of about 200 bbl. per acre. If the entire field be taken as eighty square miles, the yield per acre is a little less than 500 bbl. for the same period, with a probable future production of about 250 bbl. per acre.

A SUMMARY OF THE CANADIAN FOOTHILLS BELT

WESLEY PURDY

INTRODUCTION

Within the last few years the search for crude oil has become world wide. It is not likely that new extensive areas yielding petroleum in commercial quantities will be discovered in the United States, except, perhaps, in the southwestern states, which are now being tested. Pools may be developed from lower horizons in some of the old fields, but the limit to our oil resources appears to be in sight. Attention must be turned, therefore, to possible future supply from foreign fields.

Of the remainder of North America, much is already known of the vast quantities of oil in Mexico, but little information concerning the possibilities of Canada is available. The purpose of this paper is to give a concise description of the foothills belt of western Canada and its possibilities of oil production.

The writer spent the summer of 1919 in the foothills belt of western Alberta, and during the summers of 1914 and 1915 did field work in Montana and Wyoming.

THE FOOTHILLS BELT

The foothills belt of western Alberta lies east of the Front Range of the Rocky Mountains, between the mountains and the plains. Parallel to the mountains the belt extends northwest from the International Boundary into British Columbia and south into Montana, a distance of about eighty miles beyond Sun river.

For convenience the belt may be divided into three zones characterized by distinctive topography and geologic structure. (1) The Zone of Intense Folding and Faulting is marked by sharp ridges disposed *en echelon*, parallel to the general axis of the mountain ranges on the west. The ridges are overthrust fault escarpments, the beds being in general inclined to the west. The rocks are sharply

Wesley Purdy, Carter Oil Co., 26 Broadway, New York, N. Y.

folded and faulted. (2) The Zone of Moderate Folding and Faulting, which includes the central portion of the foothills belt, uperficially resembles the first zone in topography, but the ridges are generally longer and are not so high or abrupt. One ridge follows in line with another rather than *en echelon.* In this zone the beds are not so closely folded and faulted. There are anticlines and synclines with dips to the east and west ranging from 0 to 90 degrees. (3) The Zone of Comparatively Undisturbed Strata borders the plains country into which it topographically merges. It is distinguished by rolling hills and comparatively horizontal strata.

The major streams of the foothills belt run transversely to the general strike of the ridges, cutting deep narrow gorges through the hills as they cross from west to east. In the area north of Calgary, rock exposures are only seen in cut banks of these streams on account of the heavy growth of timber on the hills.

GENERAL GEOLOGY

The sedimentary rocks of the foothills belt of western Alberta and eastern British Columbia range in age from Jurassic to Recent. Rocks older than the Jurassic are exposed in the Rocky Mountains to the west or in outliers. The formations of the foothills region in order from oldest to youngest, with their approximate thickness, is shown in the following table:

Formations of the Foothills Region of Western Alberta:

	Thickness, feet
Tertiary:	
Paskapoo sandstone	?
Willow Creek sandstone	5000
Cretaceous:	
St. Mary's or Edmonton sandstone	1000
Bearpaw shale	300-0
Belly River sandstone	1,000-1,500
Benton formation	1,000-1,300
Upper Benton shale	
Bighorn sandstone	
Wabiabi shale	
Dakota (or Blairmore) sandstone	1,000
Kootenai sandstone and shale	?
Jurassic:	
Fernie shale	

The Tertiary formations appear on the east side of the foothills belt and increase rapidly in thickness in the geosyncline to the east.

The Cretaceous comprises most of the foothills region all along the front of the Rockies. The Edmonton sandstone, locally known as the St. Mary's sandstone, and the Belly river sandstone, in the upper part of the series, are separated by the Bearpaw shale south of Calgary. The two sandstones are both partly fresh water and partly brackish water deposits, are only slightly fossiliferous, and are not readily distinguishable on any physical characters. Both contain the pelecypod *Unio danae*, but the Edmonton contains rather more fossils than the Belly river. In the vicinity of Calgary the Bearpaw shale disappears and does not reappear to the north. The transition from the Belly river to the Edmonton is here marked by a series of alternating dark reddish brown or black greenish shales and gray sandstone beds, each a few feet in thickness. The shales contain concretions which are not fossiliferous. In some of the structures it is difficult to distinguish the Edmonton from the Belly river where the Bearpaw is missing.

In the vicinity of Rocky Mountain House a sandstone member, the Bighorn, appears in the Benton shale. It extends northward, but is absent to the south.

The Dakota sandstone resembles the Edmonton and Belly river, but weathers with a more vivid coloring. Its basal portion consists of a conglomerate bed a few feet thick, which is a widely traceable horizon marker north of Calgary.

OIL DEVELOPMENT

Of the fifty or more wells which have been drilled to the present time in the foothills region, hardly one-fifth have been located favorably or penetrated oil horizons. Half of the remaining wells failed through lack of knowledge of geologic conditions, poor locations or lack of capital. Some wells were drilled on structures which were too badly faulted to be favorable, and in some cases minor folds east of the main axis have been mistaken for the crest of the main structure. Several wells were started with diamond drills which could penetrate little more than 1,000 feet and were abandoned. Other wells were entirely speculative.

Most of the wells were drilled at the time of the Calgary oil boom in 1914, when it was supposed that oil had been discovered in the

Dingman well southwest of Calgary. This well proved to be unproductive. Through the war period little has been done except where production has been obtained. With the return to normal conditions it may be anticipated that the foothills region may be thoroughly tested.

There is little likelihood of discovering good production in the Zone of Intense Folding and Faulting on account of the extensive breaking of the formations and the compression. However, oil has been reported from this zone at a point near the International Boundary where the Cretaceous, which evidently contains the oil, has been overridden by the Carboniferous, thrust faulted from the west.

The Zone of Moderate Folding and Faulting offers the most encouraging opportunities for oil development since here are found well defined structures which, at least in part, may not be too extensively broken by faulting to permit the accumulation of oil in commercial quantities.

The Zone of Comparatively Undisturbed Strata offers less encouraging prospects of commercial production than other parts of the foothills belt or than the structurally similar region in Wyoming and Montana on account of the narrow width of the belt in Alberta and the very gentle inclination of the strata. A short distance eastward toward the broad geosyncline, which lies east of the mountains, the Cretaceous is very deeply buried.

Unfortunately, as in most of the foothills belt, the country in this zone is thickly forested. No drilling for oil is permitted within the Forest Reserves of Alberta, according to laws enacted before the existence of petroleum in this belt was known. Mining claims may at present be staked, and since there is no apparent reason for a restriction of drilling, it is probable that the statutes will be altered. Less of the Forest Reserves lie in this zone than in that to the east. The areas not covered by woods are in most cases easily accessible by roads from the Canadian Pacific railway, a distance of not more than forty miles. In the forested areas roads are few and very poor. They may become almost impassable in bad weather. Some parts of the foothills belt in Alberta lie as much as eighty miles from the railroad, and in British Columbia much farther.

COMPARISON OF ALBERTA AND BRITISH COLUMBIA WITH MONTANA AND WYOMING

In some respects the foothills belt of western Alberta resembles the corresponding belt in Montana and Wyoming, but in others there are marked contrasts.

Conditions common to both areas may be noted as follows: (1) The Colorado shale and the Kootenai formation, which yield oil and gas, underlie the greater part of both regions. (2) The belt of folded and faulted strata along the front of the Rocky Mountains is present in both regions. (3) In the area east of the disturbed belt in both regions great thicknesses of nearly horizontal strata without strongly marked structural features overlie the possible productive formations.

In contrast with the portion of the foothills belt in Montana and Wyoming (1) that in Alberta is very narrow, not extending over more than two degrees of longitude. The corresponding belt of structure favorable for the accumulation of oil and gas south of the International Boundary extends approximately eight degrees east of the mountains. (2) East of the Rocky Mountains in Montana and Wyoming are igneous rocks in the form of laccoliths, which make a number of isolated mountain groups. In the vicinity of these intrusions the otherwise more or less horizontal beds have been upturned, and at least in Wyoming favorable structures for the accumulation of oil have been formed a considerable distance from the Rockies. No isolated mountain groups occur in western Alberta or the foothills belt of British Columbia east of the Rockies, and there is a marked absence of igneous intrusions. (3) In the main, structures may readily be determined in Montana and Wyoming. In Alberta, however, widespread deposits of surface gravels and glacial till obscure the bed rock and there is meagre opportunity for structural study.

RELATION OF QUALITY OF OIL TO ORIGIN

The oil which has been found in the Canadian foothills belt is a very high grade, light, paraffin base oil with a large percent of gasoline. This character appears to be associated with the disturbed condition of the foothills structure and points to the migration of the oil from its original source during which it has undergone a filtering

and clarifying process. As reported by S. E. Slipper, of the Canadian Geological Survey, drilling on the Turner Valley anticline has not encountered water bearing beds:

> "If water is not present in Dakota-Kootenai rocks the ground water level, and consequently the oil accumulation, must be well down on the flank of the eastern limb, or even in the central portion of the large syncline, and it may be that the very light grade oil now being obtained is merely an accumulated condensation collected at the apex of the fold, or oil vapor from the gas given off by the oil body, or only the top of the main pool has been penetrated where the light petroleum products have separated out from the heavier constituents lower down."

So far as the writer is aware all the oil which has thus far been obtained comes from dry sands. It is then not improbable that the mother pool lies well down the syncline, having migrated there from lower horizons through faults, which in this field accompany most of the anticlines on the west dipping flanks. The actual production is in no case more than five barrels per well, and in most cases less. May not the oil which is obtained have been forced to the crests of the folds by the accompanying gas?

On most of the anticlines it is not advisable to drill far down on the flanks, on account of the steep inclination of the beds and the great depth of the oil bearing sands. Tests could, however, be made on the sides of anticlines with gently sloping limbs.

THE RELATION OF THE BURIED GRANITE IN KANSAS TO OIL PRODUCTION

RAYMOND C. MOORE

INTRODUCTION

In June, 1914, oil was discovered in the Augusta gas field, central Butler county, Kansas. A number of wells were quickly drilled, and it was shortly demonstrated that here was one of the important oil fields of the state. The following year, 1915, guided by geologic evidence of favorable structure in the vicinity of El Dorado, some fifteen miles to the northeast, the Empire Fuel and Gas Company drilled a well which found commercial production of oil in two different sands. This was the beginning of the El Dorado field, one of the most important in the Mid-continent region. Production culminated in 1917-18, with the very large wells in the Towanda district, some of which produced more than twenty-five thousand barrels per day. More recently, large deposits of oil have been found in the Peabody-Elbing fields north of El Dorado, and oil has been discovered near Florence, Marion county. Production in these fields in Butler and Marion counties has been much larger than in any other portion of Kansas.

What are the reasons for the occurrence of these very large oil accumulations some distance west of the shallow fields of eastern Kansas? What are the possibilities of finding similar conditions in other parts of the state? Which are the most favorable areas for new tests? These are important questions to the seeker for new oil fields in this part of the Mid-continent region.

THE BURIED GRANITE RIDGE

Trending east of north from the El Dorado fields is a belt of geological structure similar to the anticlines of the El Dorado and Augusta district. Wells which have been drilled along the axis of

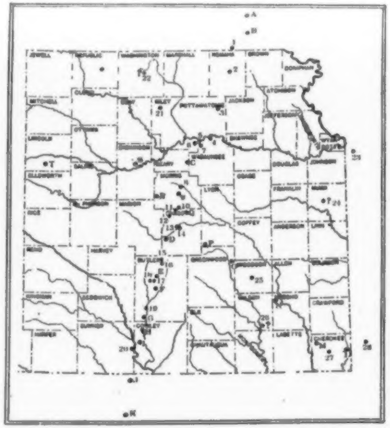
Raymond C. Moore, State Geologist of Kansas, Lawrence, Kansas.

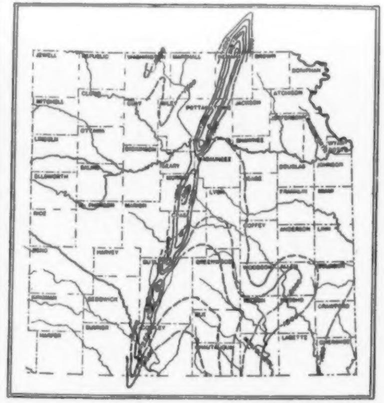
this structure have in many instances found considerable showings of oil and gas, but have encountered granite at unexpectedly shallow depths. The discovery of crystalline rocks in these wells was, of course, a disappointment which turned prospectors from the area. Recently the deeper drilling of wells in the El Dorado and Augusta districts and south of Bulter county have also shown the presence of granite beneath these oil fields. The general conditions beneath the surface in this part of Kansas, as determined by recent studies, are now fairly evident.

The granite which has been encountered is an elongated ridge which trends in a nearly straight line from north of the Nebraska state line into Kay county, Oklahoma. This ridge reaches its highest elevation near the north boundary line of Kansas, in Nemaha county, where it is less than five hundred feet below the surface. As shown in Figure 1, which is a section along the line of the granite ridge, the surface of the granite descends gradually to the south to a point in northwestern Wabaunsee county where it declines sharply in a saddle, rising in Morris county and in Chase county in peaks of different elevations. Beneath the El Dorado and Augusta fields in Butler county there are uplifted portions of the granite, while between the productive areas the surface of the granite is depressed. Southward into Oklahoma the surface of the granite is gradually lower. The geographic position of the granite ridge, the elevations of its surface, and its relation to the sedimentary rocks which surround and bury it, are now fairly shown by the drilling which has been done.

SEDIMENTARY ROCKS NEAR GRANITE RIDGE

The sedimentary rocks which appear to be in contact with the granite ridge belong to the lower Paleozoic, the Mississippian, and the Pennsylvanian geologic divisions. The higher parts of the ridge project into the Pennsylvanian strata. Beneath the Pennsylvanian lies the Mississippian, in places resting on the flanks of the granite ridge, but not extending across the higher parts; in other places, extending through the saddles of the ridge. It has been demonstrated recently that the Mississippian is an important source of oil in the Mid-continent field. In a few places, lastly, it appears that rocks of older Paleozoic age occur in contact with the granite. These are on the lower slopes of the granite.





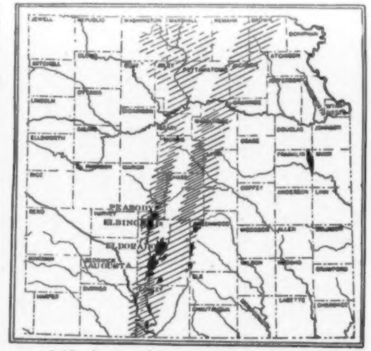
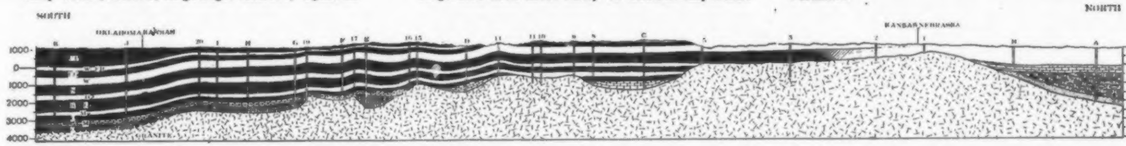
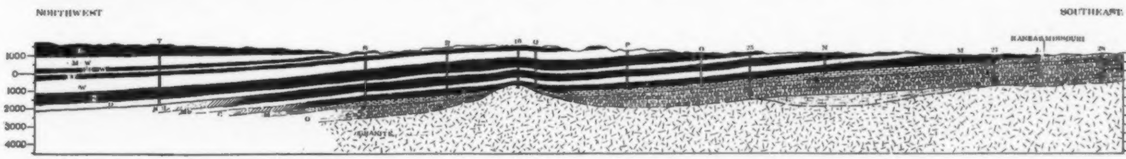


Figure at left: Map of Eastern Kansas, showing wells (numbered) encountering granite and deep wells (lettered) in geologic sections; figure in center—contour map of granite in Eastern Kansas, showing elevation of surface of granite with reference to sea level; figure at right—map of Eastern Kansas, showing oil wells adjacent to granite ridge and area most likely to contain important new fields; figure at bottom–geologic sections along granite ridge (above) and across ridge (below), letters and numbers refer to wells shown in top figure at left. Geologic formations: O—Ordovician; M—Mississippian; C—Cherokee; Ma—Marmaton; K L—Kansas City Lansing; D—Douglas; S—Shawnee; W—Wabansee; C G—Council Grove; W F R—Wreford to Fort Riley; U P—Upper Permian.





STRUCTURE

The geologic divisions which are recognized at the surface in eastern Kansas have been traced carefully westward beneath the surface from a study of well logs, and the geologic formations which are encountered by the drill in Bulter county and northward along the granite ridge have been identified. In conjunction with the study of the surface formations in the vicinity of the granite ridge, the structure of the sedimentary rocks and its relation to the granite have been determined from well records. It appears that the stratified rocks conform more or less closely to the surface of the granite. They bend over the ridge in an elongate arch, and along the granite they bend up over the peaks and are depressed in the saddles. The structure of the sedimentary rocks, then, appears to be controlled almost wholly by the nature of the hard granite which underlies the surface, and instead of folding by lateral pressure, it appears that the structures are the result of vertical settling or condensation of the sediments from compression by weight of overlying rocks.

RELATION TO OIL PRODUCTION

The large quantities of oil and gas in the Butler and Marion county areas which have been discovered to date, are found in sands, conglomerates, and porous parts of limestones, in the uplifted portions of the sedimentary rocks above or on the flanks of the granite. The oil in these fields comes from the lower parts of the Pennsylvanian and in part from the Mississippian. Where the granite surface is sufficiently low to permit the occurrence of the Mississippian and basal Pennsylvanian rocks above the granite, the oil is found above the crest of the ridge, as in El Dorado and Augusta. Farther north it appears that the oil is mainly on the flanks of the ridge, as at Peabody and Elbing which are on the west side of the granite. Here and farther to the north, due to the higher elevation of the granite, the oil-bearing beds do not appear to extend across the summit of the ridge. This accounts for the failure to find commercial quantities of oil in most of this area *above* the granite.

FUTURE OIL PRODUCTION

The determination of the geological relation of the oil-containing beds in Butler and Marion counties to the adjacent granite, which

has been indicated, makes clear that the most favorable area for the possible discovery of new fields is along either flank of the granite ridge where sands are likely to be present and where the strata are upturned sufficiently to produce an accumulation of oil. Favorable structural features in the belts or zones along the flanks of the buried granite offer the most likely places for the discovery of new and possibly very important oil pools. For example, on the east side of the buried granite which rises to 850 feet below sea level in the east part of Chase county, is found a geological condition which is practically identical with that on the opposite or west side of the granite near Peabody and Elbing where important oil fields have been developed. Eastern Chase county and adjacent territory is therefore an area which merits very careful examination of surface structure and considerable testing with the drill. The small but high grade oil deposits which have been developed in the Teeter field, northwestern Greenwood county, are indication of the occurrence of commercial deposits of oil in the geological situation under discussion. Very good showings of oil have been obtained in wells which have been drilled at various points on the flanks of the granite ridge, although in most instances the wells do not appear to have been located with reference to surface structural features. Where sands or other porous rock can be found beneath the surface along the sides of the granite, and the prospects for this are best not far from the granite, it appears that good oil production may be obtained. It is to be pointed out that the nearer a well is located to the position of the buried granite, which is now known with fair definiteness, the greater the risk of encountering granite before reaching productive oil horizons.

FAVORABLE AREAS FOR PROSPECTING

In view of the conditions which determine the occurrence of oil in the El Dorado, Augusta and Peabody-Elbing districts, it is evident that the most favorable areas for prospecting are those in which the conditions are as nearly as possible identical with the known producing fields. Oil may be found above the granite ridge between the El Dorado - Augusta fields and the Kay county, Oklahoma fields; for here the granite is sufficiently deep below the surface to permit the occurrence of the lower Pennsylvanian and

Mississippian oil-bearing horizons above its summit. Wells in this zone should be drilled deep into or through the Mississippian, for very good production is now being obtained in Kay county from and even *beneath* the Mississippian.[1] A number of wells which have previously been drilled in this region have, without doubt, been too readily abandoned.

Conditions which are practically identical with those in the Peabody-Elbing district obtain at a number of points along the flanks of the granite ridge north of El Dorado. Without doubt there are local favorable structures and these should be tested with wells drilled deep into the Mississippian. Unquestionably some of the oil now produced in Butler county comes from porous, cherty portions of limestones, in some instances only a very short distance above the granite. The area which, as based on his recent studies, the writer believes offer most favorable opportunities lies on either side of the crest of the granite ridge, extending an unknown distance outward from the granite (probably not more than approximately twenty miles) and an unknown distance northward along the trend of the ridge toward Nebraska. The fact that fewer indications of oil have been found in the north is not necessarily proof that oil does not occur in favorable geologic relations in that area.

CONCLUSIONS

A buried granite ridge underlies central Kansas, trending west of north from Kay county, Oklahoma, into southeastern Nebraska. The granite is nearest the surface at the north, and deepest below the surface toward the south.

The oil fields of El Dorado and Augusta overlie the summit of the depressed granite ridge in Butler county. The occurrence of the oil here is due to the arching of the oil-bearing strata above the granite.

The Peabody-Elbing and Florence fields lie on the flanks of the granite on the west side of the ridge. The relations of the strata to the adjacent granite are the underlying cause of the fields.

Prospective new fields may be found in areas where the geologic relations with respect to the granite are similar either (a) to those

---

[1]The chief production in the El Dorado and Augusta fields, it is believed, comes from the porous upper part of the Mississippian.

of the El Dorado-Augusta fields, or (b) those of the Peabody-Elbing-Florence fields.

Local surface geologic features in the areas which are most favorable should be examined by a competent and reliable geologist before a test well is located.

Test wells should be drilled well into or through the Mississippian, for important production may be obtained from this horizon.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

SOME FACTORS OF CENTRAL AMERICAN GEOLOGY THAT MAY HAVE A BEARING ON THE ORIGIN OF PETROLEUM

DONALD F. MACDONALD

COASTAL SWAMPS OF PANAMA AND COSTA RICA

A feature of Panama and Costa Rica geology is the swamps that border the coast over considerable areas. These swamps lie between a low barrier beach, which forms the present strand line and relatively higher lands a few hundred feet to a mile or more inland. (See Fig. 1.)

ORIGIN OF THE COASTAL SWAMPS

Three main conditions seem to have given rise to the coastal swamps. They are: (1) A ridge or mountain zone which forms the central axis of the Panama-Costa Rica land mass, and from which the land slopes steeply to the relatively flattish coastal areas; (2) A pronounced wet and dry season; (3) A gradual and prolonged sinking of the land mass.

Borings made to locate a proper site for Gatun dam revealed a Pleistocene channel, once occupied by Chagres river. This channel is so deep that the land mass must have stood 350 to 400 feet higher than now, during early Pleistocene time. Corroborative evidence of submergence of the land is also found in the coastal charts, for these show shallow submergence of the outer zone of the flattish coastal areas. It may be mentioned here that the latest movement of the land mass has been a slight emergence, for very recent looking raised beaches are found six to eight feet above present beach levels.

In the dry season the small streams disappear and the larger ones become mere brooks. During the wet season all the streams become flooded torrents and powerful eroding agents in the highland areas; and they come down to the lowlands overloaded, losing their coarser materials toward the head of their flood plains, and carrying

Donald F. MacDonald, 120 Broadway, New York, N. Y.

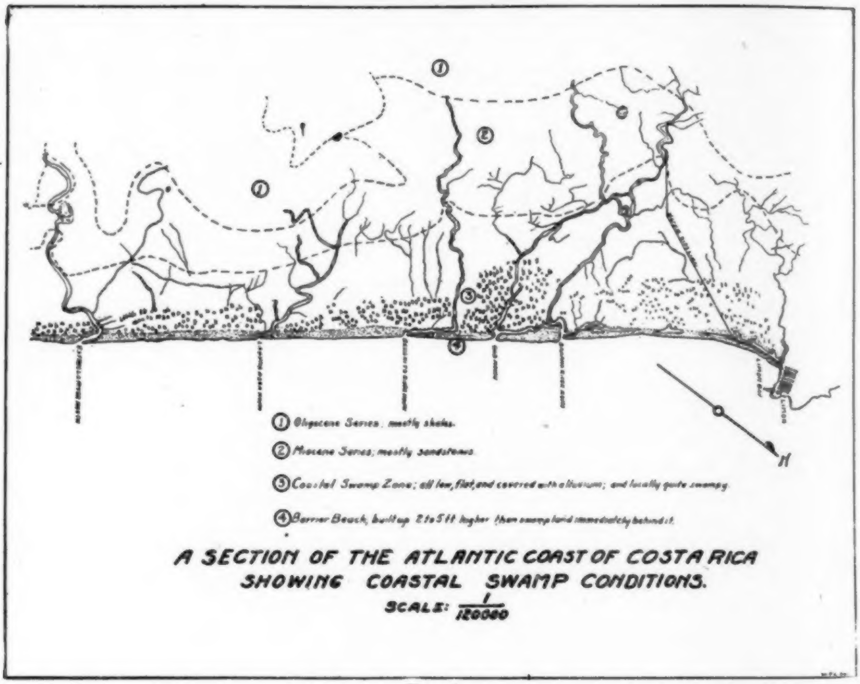

1 Oligocene Series; mostly shales.
2 Miocene Series; mostly sandstones.
3 Coastal Swamp Zone; all low, flat, and covered with alluvium; and locally quite swampy.
4 Barrier Beach, built up 2 to 5 ft higher than swamp land immediately behind it.
A SECTION OF THE ATLANTIC COAST OF COSTA RICA
SHOWING COASTAL SWAMP CONDITIONS.
SCALE: 1/120000

FIG. 1

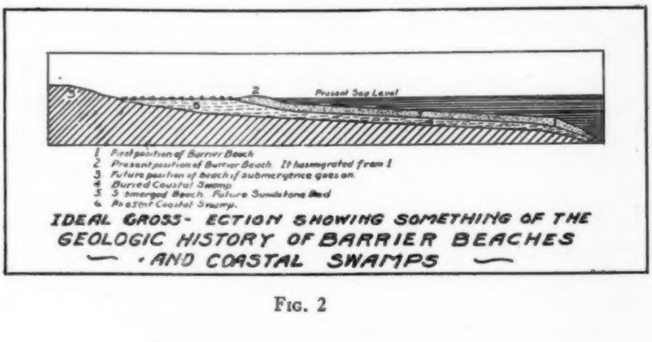

2
Present Sea Level
1 First position of Barrier Beach
2 Present position of Barrier Beach. It has migrated from 1
3 Future position of beach if submergence goes on.
4 Buried Coastal Swamp
5 Submerged Beach. Future Sandstone Bed
6 Present Coastal Swamp.
IDEAL CROSS-ECTION SHOWING SOMETHING OF THE
GEOLOGIC HISTORY OF BARRIER BEACHES
AND COASTAL SWAMPS

FIG. 2

their finer sediments out into the edge of the ocean. Shore currents distribute this material along the shores and the ocean waves pile it up as a barrier beach. This barrier beach more or less obstructs the general drainage from the flat lands behind it, and so we find coastal swamps along many parts of the coast, and especially along the oceanward fringe of the flood-plains of rivers.

SOME FEATURES OF THE COASTAL SWAMPS

These coastal swamps give prolific growth to vegetation. In the wet season they are largely covered by flood waters, which deposit small amounts of very fine sediments which gradually buries the vegetable remains that had accumulated since the last rainy season. In this way the black muds of these swamps are very rich in plant remains.

In passing over some of these coastal swamps the writer encountered small mud springs which gave off considerable hydrogen sulphide gas. It is believed that this gas is a product of the decaying swamp vegetation.

When the water was first turned into Gatun lake it covered to a relatively shallow depth great quantities of vegetation. The decay of this vegetation abstracted oxygen from the water so that the fish could not live in it. For the greater part of the first year the waters of this new lake gave off strong odors of ammonia and of hydrogen sulphide, the latter to such an extent that the red lead paint on the lock gates was partly changed to the sulphide. If the decaying vegetation covered by this wide shallow lake gave off such considerable amounts of hydrogen sulphide (and ammonia), it would seem logical to assign the hydrogen sulphide eminations, noted in some of the coastal swamps, to decay of vegetable remains buried in the swamp muds that are reached occasionally by oxygen bearing surface waters. The first rains toward the close of a dry season would tend to carry oxygen into the upper zone of these swamp muds.

A considerable amount of the sediment carried down by the rivers of Panama and Costa Rica was derived from the basic igneous rocks of the interior highlands. It is therefore very probable that some of the extremely fine sediment deposited in the coastal swamps, from river overflows during the wet season, is made up of very minute

fragments of ferro-magnesian minerals. The iron of these ferro-magnesian fragments would very probably be acted upon in part by the hydrogen sulphide in the swamp muds, resulting in the formation of pyrite. Evidence in favor of this hypothesis is as follows:

MICROSCOPIC PYRITE IN THE CULEBRA CARBONACEOUS SHALES

During the excavation of Culebra cut the shales that are rich in plant remains and marsh gas, and which locally hold some bituminous material, were also found to contain extremely finely pyrite in local areas. This pyrite was so fine that the individual crystals could scarcely be seen with the unaided eye. Its presence was determined by panning down ten or twelve pounds of the friable shale into a few ounces of concentrate.[1]

HEATING OF THE PYRITE BEARING SHALES

This finely divided pyrite was first noted because when drilled into, even at depths of 30 to 70 feet, enough air got down the 3- to 6-inch star drill hole to oxidize the pyrite and heat the hole, so that it was considered dangerous to charge for blasting. Some of the areas that were blasted heated up on exposure to the atmosphere so that they gave off steam and the odor of sulphur dioxide, and would readily char fragments of wood introduced into the heated mass. The largest of these heated areas took about three weeks to cool before it could be loaded on wooden cars. When these shales finally became cold, it was found that their carbonaceous content had been largely burned out and all their sulphides had been changed to sulphate. The carbonaceous shale horizon, which heated in this manner, is apparently the same horizon that carries good live oil seeps on both the Atlantic and Pacific coasts. It is also the horizon that was found to carry some local bitumen and considerable gas in Culebra cut.

ULTIMATE RELATIONS OF SUBSIDENCE TO THE COASTAL SWAMP DEPOSITS

The gradual sinking of the land caused the barrier beaches to migrate shoreward and gradually to bury the coastal swamps (Figure 2).

---

[1]See pages 71-74, Bul. 86, U. S. Bureau of Mines: Some engineering problems of the Panama Canal, by Donald F. MacDonald.

This would eventually result in a bed of sandstone overlying dark very fine grained carbonaceous shale very rich in vegetable remains. The sandstone would have a normal dip oceanward and would feather out against the interior land mass. When this succession of sandstone and underlying carbonaceous muds are buried deep enough with overlying shales to undergo consolidation, any petroleum material that might result from the compression of these muds rich in organic remains would be mostly squeezed out of the consolidating carbonaceous mud into the overlying sandstone, displacing some of the salt water (of deposition) that remained in the beach sands.

OILY GASES NOTED IN SWAMP MUDS

That there actually are oily gases contained in the muds of coastal swamps is supported by the following evidence:

In the edge of a bay on the Atlantic Coast of Panama, about 50 feet from the shore, small bubbles of gas were observed to rise up at intervals of 5 to 20 minutes, through 10 to 20 feet of salt water. These on bursting spread on the surface an iridescent oily film, a square inch to a square foot in area. When these films were disturbed with a stick they were drawn out, manifesting a stringiness just as a film of petroleum does. Inland from the shoreline at this point there is a slightly raised swamp. There are no trees near and the shore area contains much dead coral and coral sand.

Similar phenomena were observed by the writer in southern Alabama not far from Pascagoula. By driving a pole into swamp mud beneath relatively shallow water, very large bubbles of marsh gas come up and burst at the surface, giving of course no iridescent film. However, at intervals of several minutes, and generally after the large ebullitions of marsh gas had died down somewhat, an occasional small bubble came up and gave an intense oily iridescence on the surface water, from a few square inches to some square feet in diameter. When disturbed with a stick this iridescence was ropy in character. This same phenomenon was observed in southern Alabama in three distinct places, several miles apart, one in a fresh water swamp, one in a brackish water river estuary a few feet out from the shore, and one in a salt water river estuary near the shore. It is therefore certain, then, that a gas given off in small quantity from marsh gas-bearing carbonaceous muds contained an oily substance. It is not perhaps really certain whether this oily sub-

stance would enter into the composition of petroleum if these muds were buried beneath succeeding strata and greatly compressed, but the evidence points very strongly in that direction.

CONCLUSION

If the coastal swamps of Tertiary-Cretaceous and other geologic ages were factors in the origin and accumulation of petroleum, then the trend of the old beaches and the normal off-shore dip of the beds formed by the landward migration of the strand line would be as important or more important than the trend of subsequent folding, in determining the extension of an oil field.

PRELIMINARY NOTES ON THE GEOLOGY AND STRUCTURE OF THE AMARILLO REGION

Chas. N. Gould

INTRODUCTION

The recent discovery of large quantities of natural gas and small showings of oil in the vicinity of Amarillo, Texas, has stimulated much interest in geological conditions in that region, and in the possibility of developing an oil field there. The object of this paper, which is preliminary in nature, is to set forth very briefly our present knowledge of the geological conditions in the Amarillo region.

The gas-bearing structures in the Amarillo country were first discovered in the year 1905. At that time the writer was in the employ of the Topographic Branch of the United States Geological Survey, conducting a reconnaisance in the Panhandle of Texas, studying water supply conditions. He was assisted by two students in geology at the University of Oklahoma, Mr. Eck. F. Schramm, now professor of mineralogy at the University of Nebraska; and Mr. Tom. B. Matthews, now of Norman, Oklahoma. The party traveled over the northwestern part of the Panhandle in a covered wagon and horseback. The results of the summer's work were published in Water Supply Paper No. 191, United States Geological Survey, in 1907. In this paper three of the domes now known to be present along Canadian river were first described. These domes are now designated at the John Ray Dome, the Tuck-Trigg Dome and the Bravo Dome.

TOPOGRAPHY

This part of the Panhandle of Texas consists of a vast plain, apparently level, but in fact sloping to the east at an average rate of approximately 10 to 12 feet to the mile. The Government bench mark at Amarillo shows an elevation of 3,663 feet above sea level. Into this vast plain two streams, Canadian river and the head

Chas. N. Gould, Oklahoma City, Okla.

waters of Red river have cut channels. Red river here flows in Palodura canyon, which is the largest gash that nature has cut anywhere in the region of the Great Plains. This canyon, which is fifty miles long, is from 600 to 900 feet deep, with an average width of two to five miles. The Canadian river valley is comparatively broad and shallow. The average depth is about 600 feet below the level of the Great Plains, and the distance from cap-rock to cap-rock, north and south of the river, varies from ten to thirty miles.

GEOLOGY

The rocks of the region belong to three geological ages, namely, in ascending order: the Permian, Triassic and Tertiary.

PERMIAN

The lowest formations exposed are the upper part of the Permian "Red Beds." Of these "Red Beds" there are two definite formations, following the Oklahoma terminology, the Greer gypsums and the Quartermaster formation. Using Texas terms the rocks would be classed as the upper part of the Double Mountain formation. Greer gypsums are exposed in several places in the valley of Canadian river, but in every instance, so far as known to the writer, only where major folding has brought these rocks to the surface. The principal exposures are along the 6,666 Dome in southern Hutchinson and northern Carson counties, along the John Ray Dome in northeastern Potter county, and along the Bravo in western Oldham county. The Greer here consists of massive, white to transparent gypsum in ledges 2 to 10 feet in thickness. It is exposed, usually, in the low valley of the Canadian or along the edges of minor streams emptying into this river.

Lying above the Greer gypsum is the Quartermaster formation, 200 to 300 feet in thickness, consisting chiefly of red clay shales, and soft, red sandstone. It, however, contains two harder ledges, one of gypsum and one of dolomite. The gypsum which lies about 100 feet above the base of the formation usually consists of one or more rather soft, sometimes inconspicuous, white or crystalline ledges. It has been named the Saddlehorse gypsum. It is exposed along the sides of the cliffs bordering Canadian river or its tributaries. Lying about 100 feet above the Saddlehorse gypsum and near the top of the Quartermaster formation is a persistent ledge of dolomite,

very hard and resistant to weathering, which forms a very prominent and conspicuous marker throughout the region. This ledge was named the Alibates dolomite, and has served as a horizon of reference upon which to run levels in determining the many domes in the Panhandle country.

TRIASSIC

Above the Permian rocks, the Triassic lies uncomformably. The Triassic, as exposed in the Panhandle of Texas, usually consists of two formation: the Tecovas and Trujillo. The Tecovas formation, which is exposed in both Palodura canyon and along Canadian river, consists of 100 to 220 feet of variously colored shales. In many places, especially in the lower part of the formation, these shales are bright yellow and it is the color of these shales that gave rise to the name of the creek ("Amarillo" being Spanish for "yellow"), near the head of which is located the largest town in the region. The upper part of the Tecovas consists chiefly of maroon, magenta, lavender and white shales, sometimes in definite bands, and sometimes mixed and intermingled in great confusion.

The upper member of the Triassic, the Trujillo, is composed usually of two or three ledges of gray to brown cross-bedded sandstone, frequently conglomeratic, interspersed with two or three beds of dark red shales. The Triassic is distinctly cross-bedded throughout, and it may usually be distinguished from the underlying Permian by the difference in color of the shales. Permian shales are almost universally a bright brick red. Triassic shales are of many colors, including yellow, maroon, magenta, white and dark red, but rarely show the bright brick-red color of the Permian. So far as the writer is aware the Triassic is not exposed along Canadian river farther east than the mouth of Bonita creek, about twenty miles northeast of Amarillo. From this point it thickens to the west, and on the New Mexico line has attained a thickness of several hundred feet.

TERTIARY

Tertiary rocks lie unconformably upon the Triassic and Permian. The Tertiary consists chiefly of rather loosely consolidated clays, shales, sand and gravel apparently of stream origin. Many theories have been advanced to account for the presence of the Tertiary on the Great Plains, but the consensus of opinion seems to be that

these deposits had their origin in the Rocky Mountains, the material having been carried eastward across the Plains by streams of desert habit. One prominent feature of the Tertiary is the cap-rock, sometimes called caliche, which is usually an indurated, or hardened limey clay or in some cases a fair quality of limestone. This material is in most instances exposed along the edge of the High Plains and at points where the level of the Plains breaks off into the valleys. The thickness of the Tertiary varies up to as much as 500 feet. In the vicinity of Amarillo it is 150 to 200 feet thick. It is the great water-holder of the Plains and is sometimes referred to as the "sheet water formation." Wells in the Tertiary almost invariably find large quantities of potable water, and the numerous springs in the breaks of the various streams derive their source from this formation.

STRUCTURE

The structures in which gas has been found in the Amarillo country are located near Canadian river and along this stream, some ten or twelve domes have already been mapped in Texas. They are found all the way from Plemons, Hutchinson county, westward to the west line of the Panhandle and far into New Mexico. They are rather uniform in shape but vary considerably in size. They consist of large, oval more or less symmetrical domes, with an upfold or lift varying from 200 to 500 feet, and with a major axis of from six to twenty-five miles. In the case of five of the domes, where Permian rocks are at the surface, the Alibates dolomite was used as a horizon of reference upon which to run levels. In other cases, where the Permian is not exposed on the surface, one of the ledges of the Triassic sandstone was used. In two cases the major axis of the dome lies almost east and west; in one dome it is north and south; in two cases, northwest and southeast; while in other instances the axis is northeast and southwest.

DEVELOPMENT

Up to the present time the most extensive drilling has been done on the John Ray Dome, in northeastern Potter county and southern Moore county, twenty to thirty miles north and northeast of Amarillo. The John Ray Dome is a broad, symmetrical structure lying chiefly north of Canadian river. The northwestern part of the dome is covered by Tertiary rocks, and so far as determined only about two-

thirds of the structure has been uncovered. It is fifteen to twenty miles long and eight to ten miles wide, with a lift or upfold of 500 feet. There have been six wells drilled on this structure. All of them have obtained considerable quantities of gas and each of them has a showing of oil. The first three wells drilled, Masterson No. 1, No. 2 and No. 3, were located within a mile of each other, near the apex of the dome. These wells made from 8 million to 20 million cubic feet of gas daily. Masterson No. 4 was drilled about one and one-half miles southeast of the others and perhaps eighty feet down the slope from the summit of the dome. This well, when shut in, showed 107 million cubic feet of gas daily. The log of Masterson No. 4 follows:

LOG OF MASTERSON No. 4

	From	*To*	*Strata*	
Soil	0	38	38	
Red rock	38	44	6	
Lime	44	48	4	
Gray shale	48	58	10	
Red rock	58	145	87	
Gyp	145	150	5	
Red rock	150	155	5	
Gyp	155	160	5	
Red rock	160	270	110	
Water sand	270	285	15	
Red rock	285	310	25	
Gyp	310	324	14	
Red rock	324	370	46	
Red rock and gyp	370	380	10	
Gyp	380	395	15	
Red rock	395	410	15	
Gyp	410	416	6	
Gravel	416	420	4	
Gyp	420	435	15	
Gravel	435	445	10	Water
Red rock	445	460	15	
Gyp	460	485	25	
Red rock	485	490	5	
Gyp	490	510	20	
Red rock	510	520	10	
Gyp	520	545	25	
Red rock	545	550	5	
Gyp	550	580	30	
Red rock	580	585	5	
Gyp	585	605	20	
Red rock	605	610	5	
Gyp	610	657	47	
Brown shale	657	692	35	
Quick sand	692	715	23	Water
Gumbo	715	725	10	
Red rock	725	735	10	

LOG OF MASTERSON No. 4—Continued

	From	To	Strata	
Quick sand	735	780	45	Water, set 12-in. [pipe
Red rock	780	786	6	
Blue gyp	786	805	19	
Red rock	805	940	136	
Gyp	940	960	20	
Red rock	960	1,020	60	
Gyp	1,020	1,045	25	
Red rock	1,045	1,095	50	
Gyp	1,095	1,140	45	
Red rock	1,140	1,150	10	
Gyp	1,150	1,170	20	
Red rock	1,170	1,185	15	
Gyp	1,185	1,205	20	
Red rock	1,205	1,215	10	
Gyp	1,215	1,235	20	
Red rock	1,235	1,240	5	
Gyp	1,240	1,250	10	
Red rock	1,250	1,290	40	
Gyp	1,290	1,310	20	
Sand	1,310	1,360	50	
Red rock	1,360	1,370	10	
Sand	1,370	1,420	50	
Red rock	1,420	1,425	5	
Brown shale	1,425	1,470	45	
Red rock	1,470	1,490	20	
Lime	1,490	1,615	125	
Blue shale	1,615	1,640	25G	
Gas sand	1,640	1,645	5	½ mi. ft. Gas
Blue shale	1,645	1,660	15	2 mi. ft. Gas
Gas sand	1,660	1,665	5	
Gas sand	1,665	1,670	5	107 mi. ft. Gas

Well completed and shut in November 29, 1919.

Ranch Creek No. 1 was drilled about two miles south of Masterson No. 4, and made considerable gas. Bivens No. 1, which was drilled south of Canadian river about nine miles southeast of Masterson No. 4, and approximately three hundred feet down the slope of the anticline, is reported to have made 30 to 40 million cubic feet of gas daily. All of these wells had showings of oil and the gas is said to be rich in gasoline.

The gas is encountered in all of the wells, in a sandy shale which lies at a depth of from 1,600 feet to 2,200 feet. As nearly as the writer has been able to determine, there is no definite horizon in this sandy shale which always yields gas, but it would appear that wherever a porous or sandy place is encountered in the shale, there the gas occurs. At the present time there is hardly sufficient evidence to enable one to express a definite opinion as to the geological age of

the gas-bearing horizons. Until more complete data have been secured, any statements to this effect are likely to be misleading. The horizon, however, is probably near the base of the Permian or in the upper part of the Pennsylvanian.

A well drilled on the Tuck-Trigg Dome, about ten miles south of the summit of the John Ray Dome, is reported to have reached the depth of 3,900 feet. Gas was reported at 2,500 feet and again in large quantities, estimated as much as 20 million cubic feet daily, at 3,900 feet. The last several hundred feet of this well were drilled through lime. The summit of the Tuck-Trigg Dome is about 200 feet lower than that of the John Ray Dome.

A well drilled on the Boise Dome, about sixty miles west of Amarillo, reached 3,500 feet without encountering paying production. It is claimed that no sands were found in this well, but that the entire distance was drilled through red shale.

In the Ranch Creek No. 1, a rock was encountered which has been called granite by some geologists. Others pronounced it quartzite or hard sandstone.

One of the most important problems yet to be solved is that of the age of folding. Considerable data on this subject have been collected, but much more work needs to be done. Replies from letters to a number of geologists who have worked in the region show that ideas on the subject are at great variance. The consensus of opinion, however, seems to be that the folding probably started in Pennsylvanian or Permian times and was continued at intervals throughout the Mesozoic, culminating in Larmide times, early in the Tertiary. With these conclusions the writer tentatively agrees. So far as he knows, after twenty years' work in several states there is no definite evidence of folding in the Tertiary of the High Plains.

NEW OIL AND GAS DEVELOPMENT IN OKLAHOMA

C. W. Shannon *and* F. G. Rockwell

Drilling for oil and gas has been done or is now being carried on in every county in Oklahoma, and thirty-six of the counties of the State are to be classed as oil and gas producers. At the present time there are 25,000 wells in the State, producing either oil or gas or both The extent of the explorations and the intensity of development is greater than it has been at any time in the past.

During the month of December, 1919, 247 new sections were added to the progress development map, showing that during this month drilling operations began in that number of sections over the State where operations had not been carried on prior to that time. Sixty per cent of the "wild cat" wells drilled in 1919 proved productive. The producing areas of the State may be divided into 150 pools, each of which bears a specific name.

In 1918 the first producing well in the 2,100-foot sand was completed in the Duncan field in western Stephens county, and the Duncan and Walters district became an active zone of operation. At the beginning of 1919 this field had not proved up, but as the weeks passed the Walters, or Cotton county side of it steadily demonstrated that a pool had been opened that would cut a considerable figure in the oil history of the state. The Youngstown pool in Okmulgee county was developed in 1918, but it was short lived. Out of it, however, much good came, because operators who drilled to find a Youngstown sand and missed it, went on down and opened up a much greater store of oil in one deeper sand after another until now the 3,100-foot formation, or Wilcox sand, is the deepest pay found in the county, 800 feet below the Youngstown sand. The Youngstown pool was confined to Sections 25 and 36-14-11. The big production that resulted from the attempts to find a Youngstown extension has thus far been found in Sections 6-14-12, 7-14-12, 12-14-11, 19-15-11 and 30-15-11, with lesser success elsewhere in

C. W. Shannon, Director; F. G. Rockwell, Ass't Director, Oklahoma Geological Survey, Norman, Okla.

the western side of the county. Also it had an indirect influence on the opening of a good pool over the western Okmulgee county line in Township 15-10, in Creek county, which in turn led to operations in 15-9 and in 16-10 in Creek county, which have yet to prove themselves. The Beggs district developed into one of the most prolific pools uncovered in Oklahoma and at the close of the year was still turning out 1,000 bbl. producers at times, and its possibilities were yet a question for the future to determine, as many tests are being drilled in the hope of locating one or another of the deep sands. Okmulgee county's record for 1919 was 1,619 completed wells; initial daily production of 160,620 bbls.; 482 dry holes and 151 gas wells. In 1918 there were 1,555 completions, 81,283 bbls in new production; 381 dry holes and 147 gas wells. There was a gain in 1919 of 64 in completions; a gain of 78,337 bbls. in new production, 101 more dry holes and 4 more gas wells.

Osage county also had its best year in 1919. The rules under which the Osage operator is made to play the game necessitated quick action, which resulted in a year of great activity in the county, including a large amount of work in "outside" or wildcat territory. As a result of their work there were 2,213 wells completed in the county in 1919, new production of 142,114 bbls.; 430 dry holes and 165 gas wells. In the year 1918 the completions numbered 1,375; the initial production 61,580 bbls.; 225 dry holes and 129 gas wells. In the year 1917 there were 650 completed wells, new production of 57,161 bbls.; 61 dry holes and 69 gas wells.[1]

CADDO COUNTY

The Cement field in Caddo county received considerable attention during 1919, and there is a great deal of activity at the present time and leases have reached a very high price. There is much "wild catting" in the vicinity as well as drilling on structure. At the present time about 40 rigs are either drilling or preparing to drill. Until 1919 the field was noted especially for its gas production. The principle sands are at 1,200, 1,800, 1,850, and 2,300 feet, with deep tests encountering sands at 2,800 and 3,500 feet. At the present time there are about fifteen wells producing oil in the Cement field, making an average of about 75 barrels per day.

The structure is fairly well defined and it is doubtful if the field will be extended much beyond its present limits. However, some of the best wells recently drilled at a considerable distance from the top of the structure are most encouraging.

---

[1]Oil and Gas Journal, January 22, 1920, p. 50.

CARTER COUNTY

The Hewitt pool in T. 4 S., R. 2 W., near the Healdton field was opened about the middle of 1919, by the drilling of the Texas Company's well in Sec. 27, T. 4 S., R. 2 W. The sand was found at 2,000 feet. The initial production was at the rate of 400 barrels per day. The drilling of other wells followed and at the close of the year several wells had been completed in the Hewitt field and five separate oil bearing horizons had been discovered below the 1,600 foot level. The largest producer had an initial capacity of 900 barrels. One or more of the wells recently drilled showed two or three water sands with no oil or gas, and all indications are that the pool will be small in area but of such a character that a large quantity of oil may be produced from the field.

The Empire Gas and Fuel Company drilled a "wild cat" in Sec. 24, T. 2 S., R. 3 W., and found production of 200 barrels, of good quality oil in 18 feet of sand below 2,327 feet. The Gyspy Oil Company drilled a well to the depth of 2,200 feet in Sec. 32, T. 2 S., R. 3 W., with an initial production of 100 barrels. This well was less than two miles from the Empire well.

COTTON COUNTY

The discovery of the 2,100 foot sand in Stevens county lead to active development on the Cotton county side and to the marked development in the Walters field.

CREEK COUNTY

In T. 15 N., R. 10 E. a good pool was found during the past year and this lead to the development in T. 15 N., R. 9 E., and T. 16 N., R. 10 E. These latter areas are yet to be proved. Several miscellaneous areas in Creek county are being tested and while the decline of the main field has been very rapid several area look favorable for giving increased production.

OKMULGEE COUNTY AND ADJACENT TERRITORY

The extension and deeper drilling in the Youngstown district lead to new development in adjacent territory. The old pool was confined to Secs. 25 and 36, T. 14 N., R. 11 E. The new development in the district embraced Secs. 6 and 7, T. 14 N., R. 12 E., Sec. 12, T. 14 N., R. 11 E; and Sec. 19 and 30, T. 15 N., R. 11 E. Several sands are found, the deepest of which is the Wilcox sand at a depth of 3,100 feet, 800 feet below the Youngstown sand.

The principle area of development is known as the Beggs district and has been developed into one of the most prolific pools in Oklahoma. Several wells with a capacity of 1,000 barrels or more have been brought in. The deeper sands are at approximately 2,600 feet, 2,800 feet and 3,000 feet. Some wells have been reported as having an initial capacity of 3,000 barrels. In the latter part of 1919, the daily production of oil in the new development was 25,000 barrels.

OSAGE COUNTY

Osage county had the best year of its development in 1919, and very extensive areas have been opened up for development and will be thoroughly tested out during the present year.

STEPHENS COUNTY

At the close of 1918, the 2,100 foot sand was found in the Duncan field in Stephens county. This was proved up in 1919.

The Comanche oil field near the town of Comanche now has seven or more producing wells. Some of these are producing from the 1,400 foot sand with a capacity of from 50 to 200 barrels per well. The others are producing from the 1,800 foot sand and the average production is higher, one well at least having a capacity of 300 barrels and another, drilled in in the last few days will be good for from 200 to 250 barrels. The original well which came in at 100 barrels more than a year ago is till producing 50 barrels per day.

OTHER AREAS

Special development in the Garber and Billings field, the Yale district and the Jennings district have been made throughout the year.

STATISTICAL INFORMATION ON OIL PRODUCTION IN OKLAHOMA

The following statistics were compiled from various sources, but mainly from figures published in the Oil and Gas Journal of 1919, and others supplies by the Oil and Gas Division of the Corporation Commission of Oklahoma. It is believed, however, that the figures for 1919 will differ but little from the official figures when the latter are obtainable.

Table No. 1 give the oil production of the State by months. The State has been divided into three sections or fields, Cushing and Shamrock, Healdton (including Hewitt), and the balance of Oklahoma.

PRODUCTION FOR 1919, IN OKLAHOMA

MONTHLY PRODUCTION

1919	Cushing & Shamrock	Healdton	Balance Oklahoma
January	1,171,500	1,157,500	4,104,500
February	1,134,000	1,194,300	3,996,500
March	1,281,000	1,194,300	4,333,500
April	1,293,000	1,300,000	4,246,500
May	1,088,500	1,054,000	3,874,000
June	1,070,500	1,070,100	3,790,000
July	1,152,200	1,161,900	4,472,752
August	1,090,500	1,101,000	4,332,500
September	1,086,000	1,082,500	4,504,500
October	1,174,500	1,133,500	4,849,000
November	1,117,500	1,098,500	4,817,000
December	1,141,500	1,146,000	5,144,500
Total	23,800,700	13,693,600	52,465,252

Total production, 89,959,552 barrels.

Table No. 2 gives the various prices for the various grades of oil produced in the State throughout the year.

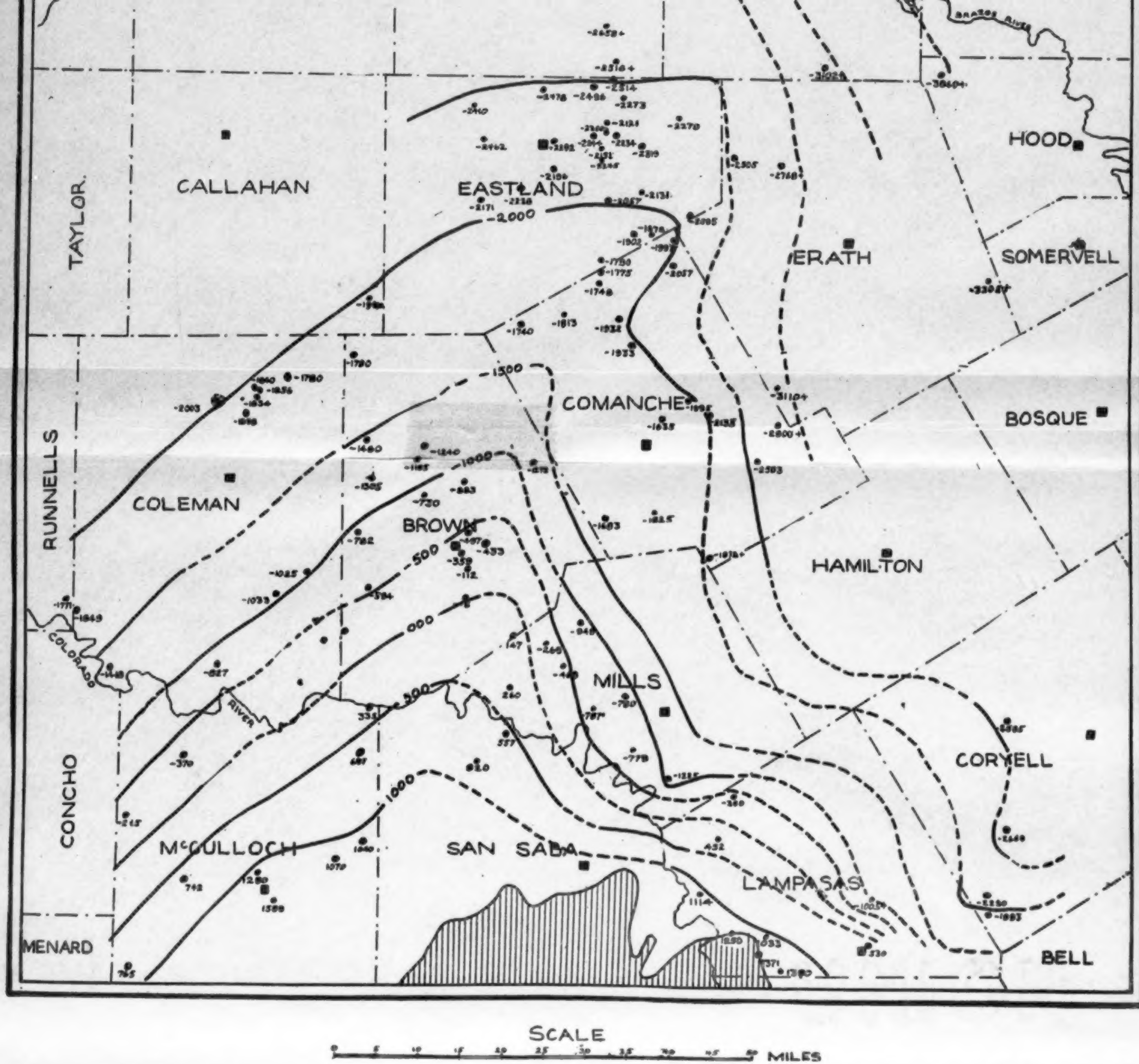
PRICES FOR OKLAHOMA CRUDE OIL IN 1919

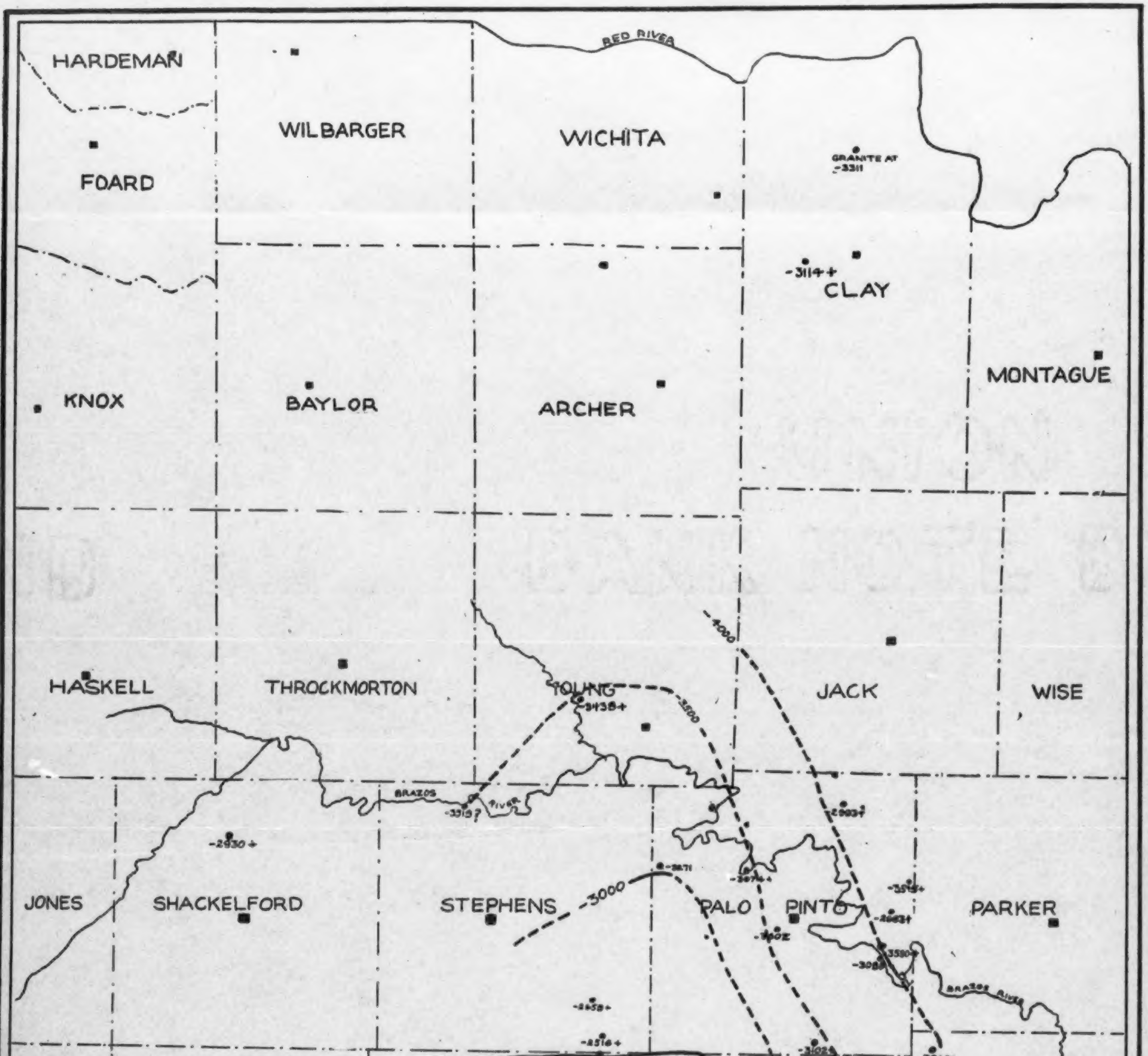
All grades, except Healdton,	Jan. 1, to Nov. 20	$2.25
All grades, except Healdton,	Nov. 20 to Dec. 22	2.50
All grades, except Healdton,	Dec. 22 to Jan. 1	2.75
Healdton	Jan. 1 to Feb 21	1.45
Healdton	Feb. 21 to Nov. 21	1.20
Healdton	Nov. 21 to Dec. 22	1.35
Healdton	Dec. 22 to Jan. 1	2.00
Hewitt takes advance over Healdton of 40c, Dec. 2.		
Hewitt	Dec. 2 to Dec. 22	1.75
Hewitt	Dec. 22 to Jan. 1	2.75
All grades, except Healdton		139,215,387.50
Healdton		17,297,485.00
Total value for 1919		$156,512,872.50

Table No. 3 summarizes the drilling for 1919 by counties, showing the percentage producing wells, percentage dry holes, and the average initial production.

RESULTS OF DRILLING IN OKLAHOMA IN 1919 BY COUNTIES

COUNTY:	Wells completed.	Wells oil	Per cent oil	Wells gas	Per cent gas	Per cent Prod.	Wells Dry	Per cent dry	Ave. Init. Prod. (Bbls.)
Carter	114	57	50	12	10	60	45	40	137
Garfield and Noble	313	217	69	24	8	77	72	23	179
Kay	247	109	44	28	11	55	110	45	172
Payne	152	111	73	19	13	86	22	14	86
Creek	477	284	60	38	8	68	155	32	52
Muskogee, Wagoner, and Rogers	710	332	47	83	12	59	295	41	57
Okmulgee	1,648	1,015	62	152	9	71	481	29	159
Pawnee	247	161	65	23	9	74	63	26	82
Tulsa	671	380	57	76	11	68	215	32	55
Nowata and Rogers	552	449	81	15	3	84	88	16	20
Osage	2,210	1,617	73	172	8	81	421	19	141
Washington	401	334	83	11	3	86	57	14	12
Wildcats and Misc.	728	342	47	96	13	60	290	40	72
Totals	8,470	5,408	64	749	9	73	2,314	27	105


TAYLOR.
CALLAHAN
EASTLAND
HOOD
ERATH
SOMERVELL
RUNNELLS
COLEMAN
COMANCHE
BOSQUE
BROWN
HAMILTON
MILLS
CORYELL
CONCHO
McCULLOCH
SAN SABA
LAMPASAS
MENARD
BELL
COLORADO
RIVER
BRAZOS RIVER
2000
1500
1000
500
000
500
1000
SCALE
0 5 10 15 20 25 30 35 40 45 50 MILES



HARDEMAN
FOARD
WILBARGER
WICHITA
RED RIVER
GRANITE AT -3311
-3114+
CLAY
MONTAGUE
KNOX
BAYLOR
ARCHER
HASKELL
THROCKMORTON
YOUNG
-3438+
3500
4000
JACK
WISE
BRAZOS
RIVER
-3319?
-2930+
-2993+
3000
JONES
SHACKELFORD
STEPHENS
PALO PINTO
PARKER
-3515+
-2663+
-3580+
BRAZOS RIVER
-2458+
-2516+

THE UNDERGROUND POSITION OF THE ELLENBURGER FORMATION IN NORTH CENTRAL TEXAS

E. H. SELLARDS

The Ellenburger limestone, approximating, when fully developed, a thousand feet in thickness, is exposed at the surface in the Central Mineral Region of Texas, and from this belt of surface exposures dips beneath later formations. To the north from the Central Mineral Region, the position of the formation is more or less well known from drilling records as far as Young and Palo Pinto counties, beyond which it passes to depths not yet reached in drilling. However, approaching the north State line it is again brought sufficiently near to the surface to be reached by a few wells in the structurally high area adjacent to Red river.

With possibly a few exceptions, the formation itself is not known to be productive of either oil or gas in commercial quantities. However, its relation to the producing formations is such that the accurate or approximate determination of its position below the surface is a matter of much importance. As a rule, test wells for oil in north-central Texas are not drilled deeper than to the Ellenburger limestone. To have a knowledge of the approximate depth at which this formation will be encountered is, therefore, important in planning a test well. In addition, the structural conditions in the Ellenburger are, with little doubt, more or less reflected in the overlying petroleum-bearing formations. Hence the structures in the Ellenburger suggest the probability of similar structures in the later formations. This paper relates to the position of the Ellenburger limestone below the surface in north-central Texas as indicated by well records.

ACKNOWLEDGMENTS

To the Director of the Bureau of Economic Geology of the Univeristy of Texas the writer is indebted not only for the opportunity

E. H. Sellards, Bureau of Economic Geology, University of Texas, Austin, Texas.

Published with the permission of the Directors of the Bureau of Economic Geology of the University of Texas.

of working on this problem, but also for access to the many data that have been accumulated in the records and files of the Bureau. For data more recently obtained, the writer is under obligation to all the large oil-producing companies operating in north-central Texas, and in particular to the geological and scouting departments of these companies, and to drillers and others. The logs of wells have been obtained either directly or indirectly from the companies testing for oil. The surface elevations at the wells where known by instrumental surveys are to be credited entirely to the operating oil companies. Where elevations based on instrumental surveys are not available, the elevations of the wells have been estimated from the topographic maps of the United States Geological Survey. The samples of cuttings, like the logs, have accumulated in the Bureau collections at different times and from various sources. Many of them have come to the Bureau from geologists, scouts, drillers, and others interested in particular wells. A considerable number of samples recently received has been contributed from the geological departments of several of the operating companies.

In connection with the discussion of the well records, the writer has had occasion to refer to and utilize the data from cuttings from numerous wells. These samples have been identified by Dr. J. A. Udden. Among those who have assisted in the identification of well samples in the Bureau of Economic Geology collections are V. V. Waite, E. B. Stiles and A. H. Kemp. In the case of two of the wells used in this report, namely the Goss and Schoor wells of Comanche and Eastland counties, the samples contained in the Bureau collection have been supplemented by the description of samples from the same wells by S. G. Garrett under direction of Wallace E. Pratt of the Geological Department of the Humble Oil Company.

PREVIOUS PUBLICATIONS

The existence of a structurally high area extending slightly east of north from the Central Mineral Region has become well known in recent years. This arch was depicted in a general way in a map by M. G. Cheney[1] published in May, 1918, and in a map by Dorsey Hager,[2] published in June, 1918. In these maps the Bend formations

[1]Oil Trade Journal, Jan. 4, 1918, p. 75.
[2]Am. Inst. Min. Eng. Bull. 138.

are used in contouring the regional structure, while the present paper relates entirely to regional structure as indicated by the Ellenburger formation. In a paper entitled Recent Knowledge of Formations Below the Bend, Mr. William Kennedy has referred to a number of wells which enter the Ellenburger formation in north-central Texas and concludes that they indicate a ridge extending in a northeasterly direction from the Central Mineral Region.[3] A similar conclusion has been expressed by W. G. Matteson. Lee Hager[4] has described the regional structure on Red river, while papers relating to structural conditions within the oil fields of north-central Texas have been published by a number of other geologists[5].

LIMITATIONS IN THE DATA NOW AVAILABLE

The present map is preliminary. It is based on the data now available in the Bureau of Economic Geology and is to be revised as data accumulate. There are certain sources of possible error among which the following, in particular, should be mentioned: The elevation of the land surface at the wells is, in all instances, to be regarded as more or less an approximation to actual levels. As already stated, in the absence of other data, some elevations, as noted in connection with the wells, have been estimated from topographic maps. These are reconnaisance maps with contours at 50-foot intervals. There is also difficulty in placing these wells accurately on the topographic map. There is thus introduced for these wells a possible error in elevation from a few feet to as much probably as 100 or 150 feet in the case of some wells. For the wells the elevation of which is based on instrumental levels, there is likewise a considerable possible limit of error in elevation. For many of these wells, two or more elevations have been recorded which seldom agree, and which vary among themselves from a few feet to as much in extreme cases as from 50 to 75 or 100 feet.

Not only in the matter of surface elevations, but in the records

---

[3]The Southwestern Oil Journal, Jan. 4, 1919, p. 1.

[4]Oil and Gas Journal, Oct. 17, 1919.

[5]Jon A. Udden: Subsurface Geology of the Oil Districts of North-central Texas; Wallace E. Pratt: Geologic Structures and Producing Areas in the North Texas Petroleum Fields; J. A. Udden: Observations on Two Deep Borings Near the Balcones Fault Zone; W. G. Matteson: A Review of Developments in the New Central Texas Oil Fields During 1918: Bull. Am. Ass'n. Petr. Geol. Vol. 3, 1919.

themselves, the data as to the Ellenburger formation are approximate rather than exact. A sample of cuttings which affords a positive identification of the Ellenburger may nevertheless be indeterminate as to whether it has been obtained from the top or from some distance down in that formation. In such instances, the data from the sample may be supplemented in an important way by the data from the log. In the case of wells represented merely by a log, the probability of error in determining the top of the Ellenburger is, of course, greater than when represented by both log and samples, and while most logs are so drawn as to permit the determination of the dividing line between the Bend and Ellenburger formations, there are some that permit at best only of an approximate separation of these formations. Nevertheless, for regional structure, it is believed that the data now available are sufficiently exact to be of service in defining both the position and the structure of this formation in north-central Texas.

IRREGULARITIES IN THE TOP SURFACE OF THE ELLENBURGER PRODUCED BY EROSION

As has been stated, the purposes of a map contouring the Ellenburger are two-fold. First of all, the map and text combined afford the driller the data by which to make such an estimate as it is now possible to give of the depth to this formation at any place within this area. Secondly, the map indicates in a broad way the regional structure of the Ellenburger formation in north-central Texas. In applying the map to the interpretation of structure, however, it must not be forgotten that the top surface of the Ellenburger is an erosion surface and that some of the irregularities in the formation may be due in part to erosion and not entirely to structure. It is certain, however, that while the erosion features may account for relatively minor irregularities in the Ellenburger, the major features observed and mapped in that formation are structural.

EXPLANATION OF THE MAP

The location of each well used in determining the position of the Ellenburger limestone is indicated with such degree of accuracy as is practicable on a map of this scale. In the case of those wells believed to have entered the Ellenburger formation, the approximate actual level of the top of the formation above or below sea level,

as nearly as that can be determined, is shown by the map entry for that well, levels below sea being indicated by a minus sign preceding the number. In addition to wells entering the Ellenburger a few have been used which, although not known to have entered the Ellenburger, are useful in mapping as showing that the formation lies below a given depth. In the map entry such wells are indicated by a plus sign following the entry. Dotted contours include those farther removed from known wells and hence less definitely placed than the contours shown in solid lines.

REGIONAL STRUCTURE IN NORTH-CENTRAL TEXAS AS INDICATED BY THE ELLENBURGER FORMATION

Contours on the Ellenburger, as on the Bend, indicate a pronounced arch extending slightly east of north from the Central Mineral Region. From near the western part of San Saba county the axis, or line of maximum elevations on this arch, passes somewhat east of the center of Brown county, crosses the northwestern part of Comanche county, and lies probably somewhat east of the center of Eastland county. North of Eastland county the available data are as yet too limited to locate the ill-defined axis of the fold in the Ellenburger, which probably lies near the Stephens-Palo Pinto county line.

This fold plunges to the north, the rate of plunge varying from place to place. In San Saba and McCulloch counties the Ellenburger is found at the surface at elevations of from 1,500 to 1,700 feet or more above sea level. In Young county, 150 miles to the north, the formation lies 3,500 feet or more below sea level. The plunge is probably most rapid in Brown county where it may amount to as much as an average of 50 feet per mile. Farther to the north the plunge in the axis of the fold is less rapid, and over considerable distances may not exceed 25 or 30 feet per mile.

A conspicuous feature of this large fold is the lack of symmetry between the west and east sides of the arch. The west limb of the arch has an approximately uniform slope, decreasing in rate of dip perhaps with the increased distance from the Central Mineral Region. On the east limb of the fold, on the other hand, the rate of slope is notably irregular, and is in general more rapid than on the west limb. In contouring, this lack of symmetry in the fold is expressed by the

abrupt turn of the contours to the south after crossing the axis of the fold. On the west side of the fold the contours, when drawn to express regional structure, and disregarding such local structures as may exist in this formation, maintain an approximately regular course, varying in direction from north-northeast, west of the mineral region, to east-northeast and in places almost east-west as they approach the axis of the fold. After crossing the axis, these contours turn shortly to the south and in some instances turn southwest, thus almost doubling back on themselves.

The arch, as developed in the Ellenburger, is not a simple fold. Masses or "noses" of this formation project to the northeast. One of the best delineated of these noses is that at Desdemona. Here the contours on the Ellenburger, after making the turn at Desdemona, run west of south until again deflected to the east by another northeastward projecting mass of the Ellenburger. The 2,000-foot contour below sea level, after turning south near Desdemona, runs west of south for as much as 15 miles to the Tate and Fisher wells where it turns at right angles to a direction slightly south of east. This contour again turns south after passing the Sturkie well northeast of Comanche. Its position at the Mills county line is defined in part by the Luckie well which indicates that its course from the Sturkie well may be about due south as drawn on the map, or very possibly when more fully known the course of the contour after making the turn northeast of Comanche may be found to be west of south into Mills county. Other contours, crossing the axis of the fold, follow a more or less similar course, at least to the extent of bending very shortly to the south.

DISTURBED AREA BETWEEN THE BEND ARCH AND THE BALCONES FAULT ZONE

Not only is the east slope of the major arch one of rapid and irregular dip, but observation will show that the whole area from the Bend Arch to the Balcones Fault Zone, at least that part of it in which the Ellenburger formation can now be delimited, is an area of much greater disturbance than is a similar area to the west of the Bend Arch. The northeastward projecting masses of the Ellenburger at Desdemona and northeast of Comanche have been referred to, the syncline separating these being located by the Tate and Fisher wells and expressed on the map by the deep reentrant in the contours.

A very deep reentrant in the contours, in the eastern part of Mills county, indicates the location of another structurally low area in the Ellenburger. This low area in Mills county contrasts strongly with the broad high Ellenburger mass extending into the northwestern part of Lampasas county. The broad high area of Lampasas county is interpreted in contouring as continuing to the northeast to the Clark well in Coryell county. However, as there are at present no deep wells in northeastern Lampasas and northwestern Coryell counties, this mapping of the Ellenburger lacks confirmation and may ultimately require alteration. Another low is indicated, the writer believes, by the wells of eastern Lampasas and southwestern Coryell counties, including the Grove well of Lampasas county and the Tinery and Strickland wells of Coryell county. The Gotcher well near the Coryell-Bell county line with little doubt indicates the approach to the relatively high area of the Balcones fault zone lying next to the east of the low area referred to. The number of wells reaching the Ellenburger is as yet limited as compared to the large area to which this map relates, and more complications in the structure of the Ellenburger are to be expected than can now be indicated in contouring. The map should, therefore, be regarded as preliminary and drawn for the purpose of expressing the present available records on the formation. The data on which the map is based are more fully given in the pages which follow.

CONDITIONS IN NORTH TEXAS

The arch in the Ellenburger formation may be followed more or less definitely, as already noted, as far to the north as Young county, where by reason of the north plunge of the structure it lies at a depth of 3,500 or 4,000 feet below sea level. That the north plunge does not continue uninterruptedly to the north state line is indicated by well records available from Clay, Montague and Cook counties. A well on the Byers farm, 12 miles north of Henrietta in Clay county, is reported to have entered granite at 4,240 feet from the surface, or at an actual level of about 3,311 feet below sea level. A well in the northern part of Montague county is known to have entered schists at 3,007 feet from the surface. In Cooke county, a few miles north of Myra, the Ellenburger is represented by samples at a depth

of 2,105 feet from the surface,[6] or at an actual level approximating 1,000 feet below sea. These records indicate that the Ellenburger formation, where present in these counties, lies at a level much higher than in the adjoining counties to the south. The conditions in the Red river area have been discussed by Lee Hager, in the paper to which reference has already been made.

AVAILABLE DATA

The data available on wells reaching the Ellenburger formation in north-central Texas are summarized in the following lists in which, for convenience of reference, the wells are arranged by counties. The wells of each county are listed alphabetically under the name of the owner of the land on which the well is located. For each well there is given the name of the company or individual by whom the well was drilled; the location by survey; the location in miles from a town or other designated place; the total depth of the well, if known; the elevation of the land surface at the well; the depth from the surface to the Ellenburger limestone; the kind of data available, whether a log or sample or both. In the case of a number of wells, although samples are at hand showing the presence of the Ellenburger, the log must be relied upon to determine the top surface of that formation, the samples having come from below the top of the formation. In such instances the entry showing the top of the Ellenburger is taken from the log, and there is added an entry showing the depth at which the first Ellenburger sample is available. There is added a column in the lists giving a map entry for each well on which the data are sufficiently complete to permit of its use in mapping, except when followed by a plus sign, the map entry indicates the depth of the Ellenburger formation below or above sea level, as nearly as can be determined. When followed by the plus sign, the map entry shows that although the well was drilled to the depth indicated, the Ellenburger was not reached, and lies at an undetermined distance below that depth. Those wells, the elevation of which is estimated from the topographic map, are indicated by the letter "T" following the entry. The elevations given for all other wells are elevations obtained from operating companies in this section and are based on instrumental levels.

---

[6]The University of Texas, Handbook Series No. 1. J. A. Udden, p. 55.

BROWN COUNTY

Name of Well and Owner	Location by Survey	Location from Town or Other Place	Total Depth	Surface Elevat'n	Depth Ellenb'rger	Kind of Record	Map Entry
Abney 1, Graham, Ludlow & Thomas	Keer Co. Sch. Lds. Sur. 272	6 mi. S. 2 E. Brownwood	2,610	1,504	1,510	Log	-6
Alvis 1, Oil States Petr. Co.	H. T. & B. Ry. Co. Sur. 37	12½ mi. N. 1 W. Bangs	3,160	1,575	3,035	Log	-1,460
Andrews 1, Pippin Oil Co.	H. H. Hall Sur. 49	½ mi. S. ¾ E. Brownwood.	2,401	1,316	1,675	Log S. 1,921	-359
Baugh 1, Bartles, Duminel & Tex. Co	Osborn Dalton Sur. 26	7½ mi. N. 1½ E. Brownwood	3,310	1,395	2,278	Sam.	-883
Burns 1, Gilman Crabtree & Simmons	C. C. Baker Sur. 7	12 mi. N. 6 E. Brownwood	3,250	1,721	3,003	Log S. 3,070	-1272
Capps 1, Texas Eastern Oil Co.	Patrick Sullivan Sur. 7	2 mi. NE. Brownwood	1,900	1,377	1,874	Sam.	-497
Cross 1, A. A. Peard	E. D. Prewett Sur. 13	S. county line	2,803	1,417	1,270	Log	-147
Davis 1, Carter, et al.	Jas. Bird Sur. 102	5 mi. S. 1 W. Bangs	2,218	1,553	2,147	Log S. 2,190	-594
Fuller 1, Empire Gas & Fuel Co.	C. B. Jennings Sur. 353	2¼ mi. W. 1¼ N. Bangs	3,708	1,563	2,345	Log	-782
Gaines 1, Sinclair Gulf Oil Co.	Nancy Jordan Sur. 12	12 mi. N. 4 W. Brownwood	2,778	1,520	2,760	Log S. 2,763	-1240
Gehike 1, Perry-Bendini	Kerr Co. School Lands	5 mi. S. Brownwood	2,105	1,400	....	Sam. 2,105	....
Harris 1, Pennant Oil Co.	Jno. Saunders Sur. 162	4 mi. fr. N. ½ fr. W. Co. line	3,405	1,625	3,405	Log	-1780
Low 1, D. R. Bailey, et al.	J. M. Baker Sur. N. part	8½ mi. N. 1 W. Bangs		1,450T	2,755	Sam.	-1,305
Lowe 1, J. W. Collins	Reuben Ross Sur. 44	3 mi. S. 1½ E. Brownwood	1,565	1,375T	1,487	Log	-112
Matlock 1, Pecan Bayou Oil Co.	Brown Co. Sch. Land Sur. 360	3½ mi. E. Brownwood	2,757	1,417	1,850	Log S. 2,380	-433
Nevermind, Producers Oil Co.	....	Southern part county	1,975	....	1,780	Log	....
Sewell 1, E. J. McJunken, et al.	T. & P. Ry. Co. Sur. 3	10½ mi. N. 5 W. Brownw'd	2,505	1,500T	2,230	Log	-730
Sterns 1, Jewel Oil Co.	A. D. Neill Sur. 41	10 mi. S. 4 W. Bangs	2,084	1,515T	....	....	....
Weeden 1, Partridge Oil & Gas Co.	H. T. & P. Ry. Co. Sur. 51	10½ mi. 5 W. Brownwood	2,760	1,492	2,657	Log	-1165

CALLAHAN COUNTY

Name of Well and Owner	Location by Survey	Location from Town or Other Place	Total Depth	Surface Elevat'n	Depth Ellenb'rger	Kind of Record	Map Entry
Vestal 1, New Southern Oil Assn.	Jesse Dyson Sur.	1½ mi. E. 1½ N. Cross Plns.	3,755	1,846	3,725	Sam	-1940
Childs 1, F. E. Henderson, et al	John Sayers Sur.	10 mi. S. 3 E. Putnam	4,005	1,785	....	Sam.	....

COLEMAN COUNTY

Name of Well and Owner	Location by Survey	Location from Town or Other Place	Total Depth	Surface Elevat'n	Depth Ellenb'rger	Kind of Record	Map Entry
Guthrie 1, Producers Oil Co.	Bond & Saunders Sur. 78	1½ mi. S. ½ W. Trickham	1,975	1,400T	....	Log	....
Guthrie 1, Santa Anna Indus. Co.	Bond & Saunders Sur. 110	1⅛ mi. W. Trickham	1,904	1,400T	....	Log	....
Guthrie 1, The Sun Company	H. E. & W. T. Sur. 117	7 mi. S. 3 W. Trickham	2,267	1,400T	....	Log	....
Harris 1, Slick Oil Company	H. Stearns Sur. 63	2½ mi. S. 1½ E. San. Anna	3,264	1,600T	2,625	Log	-1025
Miller 1, Systems Oil Company	Ft. Bend Co. Sch. Lands Sur.	Near SW. cor. Coleman Co.	3,175	1,500T	2,918	Log	-1418
Morris 4, Magnolia Petr. Co. and Elizabeth Oil Co.	David Breeding Sur.	9½ mi. N. 2 E. Coleman	3,978	1,583	3,417	Log	-1,834
Morris 3, Magnolia Petr. Co. and Elizabeth Oil Co.	David Breeding Sur.	NE. Morris 4	3,438	1,582	3,432	Log	-1,856
Morris 5, Magnolia Petr. Co. and Elizabeth Oil Co.	David Breeding Sur.	N. Morris, 4	3,430	1,578	3,418	Log	-1,840
Neff 1, Sinclair-Gulf Oil Co.	Geo Eubanks Sur. 173	11 mi. N. 7 E. Coleman	3,425	1,622	3,402	Sam.	-1,780
Padgett 1, Sinclair-Gulf Oil Co.	Brazoria Co. Sch. Lds. Sur. 226	Near SW. cor. Coleman Co.	3,580	1,596	3,445	Sam. & Log	-1,849
Sealey-Hutchins 1, Sinclair-Gulf Oil Co.	G. M. & N. Sur. 231	9 mi. N. 2 W. Coleman	3,922	1,882	3,885	Log	-2,003
Sealey & Smith 1, Magnolia Petr. Co. and Elizabeth Oil Co.	H. H. H. Ry. Co., Bl. 2, Sur. 9	7 mi. N. 1½ E. Coleman	3,610	1,632	3,530	Log	-1,898
Slate 1, Mangolia Petr. Co. and Elizabeth Oil Co.	J. Kaufman Sur. 237	23 mi. S. 2 W. Coleman	3,114	1,400T	2,227	Log	-827
Wallace 2, Robertson and Son	Wm. Ferris Sur. 279	7 mi. S. Santa Anna	....	1,500T	2,533	Log	-1,033

COMANCHE COUNTY

Name of Well and Owner	Location by Survey	Location from Town or Other Place	Total Depth	Surface Elevat'n	Depth Ellenb'rger	Kind of Record	Map Entry
Armstrong 1, P. L. Tippit	H. T. & B. Ry. Co. Sur. 13	3 mi. N. 2 E. Comanche		1,250T	2,855	Sam.	-1,635
Bender 1, Henderson, et al	J.P.Stevenson Sur.3 SE. part	2½ mi. E. 1½ N. De Leon	3,500	1,247			
Davis 1, Sam Davis Oil Co	Jas. Walker Sur	Comyn Station	3,500	1,250			
Fine 1, Lone Star Gas Co	E. T. Ry Co. Sur. 35NW. pt.	16 mi. E. 2½ N. Comanche	4,150	1,350T		Log	-2,800+
Fisher 1, Copperas Creek Oil Co	D. H. McFadden Sur. 190	11 mi. N. 2 W. Comanche		1,271	3,204	Log	-1,933
Fritz 1, Maxwell and Ertel	Geo. L. Addison Sur. SE. cor.	5 mi. N. 5 E. Comanche	3,276	1,150T	3,145	Log	-1,995
Galloway 1, Lone Star Gas Co	H. & T. C. Ry. Co. Sur. 15, SW. cor.	9 mi. S. 4½ W. Comanche	3,525	1,700T	3,883	Log	-1,683
Goss 1, Humble Oil & Rfg. Co	D. & D. Asylum Lds. Sur. 59, NE. cor.	4 mi. W. Sipe Springs	3,275	1,532	3,272	Sam.	-1,740
Gregory 1, Texas Penn	W. R. Gregory Sur. N. cor.	½ mi. from E. ⅛ from N. county line	3,410	1,400T			
Hamlin 1, Manhattan Oil Co	D. & D. Asylum Lds. Sur. 23	1½ mi. N. Duster	3,176	1,402	3,150	Sam.	-1,748
Hilly 1, Gates Oil Co	L. Birdsall Sur 54, NW. cor.	2 mi. fr. N. 1¼ fr. E. Co. line		1,343	3,340	Log	-1,997
Kee 1, Henderson, et al	J.P.Stevenson Sur.10 NW cor.	5¾ mi. S,½W. Desdemona		1,258	3,325	Sam.	-2,057
Huckabee 1, Home Boy's Oil Co	E. Moore Sur	3 mi. W. ½ S. DeLeon	3,500	1,238			
Lucky 1, Thomas and Ludlow	E. T. Ry Co. Sur. 6	1¼ mi.fr.S. ½ fr W. Co. line	3,456	1,484		Sam & Log	-1,972+
Montgomery 1, Maxwell & Ertel	Robt. Page Sur. SE. cor	5 mi. E. Mercers Gap	3,500	1,420	3,245	Log	-1,825
Moore 1, Gulf Production Co	E. Whitesides Sur. 71	12 mi. E. 2½ S. Comanche	3,824	1,193	3,776	Log	-2,583
Pittman 1, National Refining Co	H. & T. C. Ry. Co. Sur. 42	4 mi. N. 4 W. DeLeon	3,410	1,325T			
Rudd 1, Roxana-Wallace Oil Co	D. & D. Asylum Lds. Sur. 17	N. Co. line, 10½ mi. fr. NE. cor.	3,076	1,300	3,075	Log	-1,775
Small 1, Humble Oil & Ref. Co	D. & D. Asylum Lds. Sur.	2 mi. N. ¼ E. Sipe Springs		1,500T	3,313	Log S. 3,545	-1,813
Shearer 1, Texas Penn	G. Fay Sur. 53 N. cor.	½ mi.fr.N. 1½ fr.E.Co. line	3,450	1,400T			
Studeville 1, Miller, Knight & Chass	E. Whitesides Sur. 71	12 mi. E. 2½ S. Comanche	3,850	1,150T			
Sturkie 1, Comanche Oil Assn	Asa Hoxey Sur	2 mi. E. Hasse, 7¾ E. 3½ N. Comanche	3,350	1,200T	3,335	Sam.	-2,135
Tatel, Crawford & Flynn	H. & T. C. Ry., Bl. 2, Sur. 7	6½ mi. W. DeLeon	3,323	1,369	3,301	Log	-1,932

CORYELL COUNTY

Name of Well and Owner	Location by Survey	Location from Town or Other Place	Total Depth	Surface Elevat'n	Depth Ellenb'rger	Kind of Record	Map Entry
Clark 1, Benedum & Trees	G. W. Carlile Sur.	9 mi. W. 1 N. Gatesville	3,630	870	3,465	Sam.	-2,595
Gotcher 1, N. Y. Syndicate	W. T. Whitley Sur.	2¼ mi. W. ½ S. Copperas Cove	3,035	1,132	3,035 3,025	Sam. Log	-1,893
Strickman 1, Buckeye Mid-Kansas	John Winn Sur.	1½ mi. S. ¾ W. Pitcock	3,628	946	3,615	Sam.	-2,669
Tienert 1, N. Y. Syndicate	Elizabeth Jones Sur.	1½ mi. W. 2 N. Copperas Cove	3,384	1,094	3,384	Sam.	-2,290

EASTLAND COUNTY

Name of Well and Owner	Location by Survey	Location from Town or Other Place	Total Depth	Surface Elevat'n	Depth Ellenb'rger	Kind of Record	Map Entry
Allen 1, Gulf Production Co.	Wm. Fields Sur.	4¾ mi. S. 3¾ E. Ranger	4,010	1,446	3,765	Log	-2,319
Alsobrook 1, Havermeyer & Seamans	H. T. & C. Ry. Sur. 14	1½ mi. SW. Gorman	3,525	1,400	3,190	Log	-1,790
Barnes 1, Prairie Oil and Gas Co.	F. P. Barnall, Bl. 40, Sur. 657, SE. cor.	2 mi. N. 2 W. Ranger	4,300	1,584	4,080	Log	-2,496
Brashear 1, Leon Oil Co.	Wm. VanNorman Sur.	5 mi. S. ⅔ Ranger	4,000	1,477	3,628	Log	-2,151
Brashear 2, Leon Oil Co.	Wm. VanNorman Sur.	5 mi. S. Ranger	....	1,471	3,618	Log	....
Brashear 1, Westheimer, et al.	Wm. VanNorman Sur.	5½ mi. S. ⅔ W. Ranger	....	1,460	3,615	Log	....
Branford 1, Prairie Oil & Gas Co.	Rosseau Sur. 25	5 mi. S. 2¾ E. Eastland	3,955	1,479	3,717	Log	-2,238
Brown 1, Central Oil Dev. Co.	G. E. Moore Sur.	1 mi. E. ½ N. Desdemona	....	1,450T	3,545	Sam.	-2,095
Cooke 1, T. & P. Coal & Oil Co.	N. Cooper Sur.	3 mi. N. Ranger	4,200	1,546	4,187	Sam.	-2,514
Connellee 1, Benedum & Trees	N. Ussury Sur.	3 mi. S. ¾ E. Eastland	3,800	1,541	3,737	Log	-2,196
Duffer 1, Prairie Oil & Gas Co.	S. N. Mathias Sur.	1 mi. E. 3½ S. Ranger	3,770	1,446	3,680	Log	-2,234
Eppler 1, Connellee & Aguire	Wm. DeMoss Sur.	3½ mi. NE. Gorman	....	1,356	3,238	....	-1,902
Falls 1, Prairie Oil & Gas Co.	E. Finley Sur. NW. part	3½ mi. S. 1½ W. Ranger	3,700	1,441	3,685	Log	-2,244
Fee 1, Sun Company	H. T. & C. Ry. Bl. 4 NE. cor.	6½ mi. W. 1 N. Ranger	4,012	1,538	4,000	Log	-2,462

EASTLAND COUNTY—Continued

Name of Well and Owner	Location by Survey	Location from Town or Other Place	Total Depth	Surface Elevat'n	Depth Ellenb'rger	Kind of Record	Map Entry
Fee 1, Texas Pacific Coal & Oil Co.	Robertson Co. Sch. Lds. SE. pt.	8 mi. E. 1½ S. Ranger	3,710	1,250T	3,520	Log	-2,270
Hagaman 1, Lone Star Gas Co.	W. C. & C. Boswell Sur.	1½ mi. NE. Ranger	3,745	1,426	3,699	Log	-2,273
Holcomb 1, Cosden Oil Co.	J. House Sur.	1 mi. NE. Eastland	3,777	1,485	3,777	Sam.	-2,292
Mann 1, Atlas Oil Co.	Thos. Mallryne Sur (Center)	8⅓ mi. E. 2⅓ N. Carbon	3,500	1,371	3,428	Log	-2,057
Parrock 1, States Oil Corp.	H. & T. C. Ry. Co., Bl. 4, Sur. 7	6¼ mi. N. 7½ E. Eastland	4,083	1,619	4,078	Log	-2,478
Pitlock 1, T. & P. Coal & Oil Co.	Wm. Frells Sur.	2 mi. S. Ranger	4,020	1,454	3,575	Log	-2,121
Rush 1, Mid-Kansas Oil & Gas Co.	E. Finley Sur.	3 mi. S. Ranger	3,945	1,420	3,720	Log	-2,300
Shoor 1, Humble Oil Co.	H.T. & C.Ry.Co., Bl. 3, Sur. 50	6 mi. S. 2 E. Cisco	3,790	1,608	3,769	Sam.	-2,171
Stewart 1, Leon Oil Co.	Wm. VanNorman Sur.	6 mi. S. 1 W. Ranger		1,413	3,658	Log	-2,245
Underwood 1, Systems Tidal Oil Co.	D. S. Richardson Sur.	4 mi. W. ¾ N. Desdemona		1,379	3,510	Log	-2,131
Ward 1, New Domain Oil Co.	J. D. Hoxie, N. part	4½ mi. N. 1 E. Cisco	3,976	1,415	3,825	Log & Sam.	-2,410
Vaught 5, Atlantic Prod. Co.	Wm. D. Moss	3 mi. W. 1½ S. Desdemona	3,245	1,250T	3,165	Sam.	-1,915
Stockton 1, Cosden Oil Co.	Wm. D. Moss	S. County line	3,250	1,322	3,180	Sam.	-1,878

ERATH COUNTY

Name of Well and Owner	Location by Survey	Location from Town or Other Place	Total Depth	Surface Elevat'n	Depth Ellenb'rger	Kind of Record	Map Entry
Perkins 1, Baltimore-Texas Synd.	Q. Tarbox Sur. SW. cor.	7 mi. fr. W. 8 fr. N. Co. line	4,018	1,250T	....	Sam.	-2,768+
Randolph 1, Burt & Griffith	S. Blythe Sur.	6 mi. S. Dublin, 14 mi. S. 7 W. Stephensville	4,510	1,400T	....	Log	-3,110+
Thompson 1, Gulf Prod. Co.	F. R. Lubbock Sur. E. side	9 mi. S. 2 W. Thurber	3,860	1,383	3,755	Sam.	-2,505
Stacey, Sinclair Oil Co.	K. K. Koontz	3 mi. S 14 E. Stephensville	4,355	1,050T	....	Log	-3,305+

HOOD COUNTY

Name of Well and Owner	Location by Survey	Location from Town or Other Place	Total Depth	Surface Elevat'n	Depth Ellenb'rger	Kind of Record	Map Entry
Followell 1, Sinclair Gulf Oil Co.	Isaac Eaves Sur. NE. cor.	2 mi. fr. N. 2 fr. W. Co. line	4,820	980	....	Log	-3,840+

LAMPASAS COUNTY

Name of Well and Owner	Location by Survey	Location from Town or Other Place	Total Depth	Surface Elevat'n	Depth Ellenb'rger	Kind of Record	Map Entry
Abney Well, City of Lampasas		Near Santa Fe Depot, Lampasas	2,000	1,000T	470	Log	530
Conradt 1, Robarts, et al	E. T. Ry. Co. Sur. 1, SE. ¼	5 mi. N. 2. W. Lometa	2,001	1,500T	1,880	Log S Sam.	-380
Grove 1, Price, et al	R. W. Brown Sur	6 mi. N. 1 E. Lampasas	2,005?	1,100T		Sam.	-1,005+
Hill 1, Hill River Oil Co	David Evans	8 mi. S. Lometa	1,602	1,450T	417	Log	1,033
McCreel, Nelms-Marvin Oil Co	Wm. F. Nicholson Sur. 30, NW. cor.	10 mi. W. 2 S. Lampasas	1,120	1,400T	20	Sam.	1,380
Smith 1, C. H. White	T. R. Stiff, Sur. 16, S. side	13 mi. W. 1 S. Lampasas		1,400T	29	Sam.	1,371
White 1, Howell, et al	Wm. Todd, Sur. 42, NW. pt.	3 mi. S. 7 W. Lometa	1,021?	1,250T	136	Log & S 1,021	1,114
White 1, Texoleum Petr. Co	Hill Sur	13½ W. 1½ N. Lampasas		1,250T	AtSurface		1,250
Whittenburg 1, West. Lampasas	John Boyd Sur. 612, NE. cor	3 mi. W. Lometa		1,450T	998	Sam.	452

McCULLOCH COUNTY

Name of Well and Owner	Location by Survey	Location from Town or Other Place	Total Depth	Surface Elevat'n	Depth Ellenb'rger	Kind of Record	Map Entry
Baumgartner 1, Texas Hurst Synd.	P. H. Schaff Sur. 402	1½ mi. S. SE. Brady	1,253	1,650T	61	Log	1,589
Beasley 1, Dallas Milburn Valley Oil Co	F. Winkle	2½ N. 2½ E. Mercury	2,526	1,280	945	Log S. 1,012	335
Cawyer 1, Burford & Brimm	D.Mechels cor.Sur.968 NWcor	3 mi. SE. Mercury	1,422	1,422	725	Log	697
Crews 1, Southwestern Petr. Co	U. Heinrich	1 mi. SW. Rochelle	1,960	1,675T	605	Log	1,070
Craig 1, Thomas, et al	C. Usner Sur	4½ mi. N. 1 W. Melvin	2,565	1,850T	2,065	Log	-215
Morgan 1, J. E. Morgan	State Sch. Lands Sur. 2	2 mi. N. NW. Brady		1,700T	420	Log S. 680	1,280
Sellman 1, Texas Eastern Oil Co	C. Beag. Sur. 904 NW cor	3½ mi. E. NE. Rochelle	2,005	1,650T	610	Log S. 1,470	1,040
White 1, Henderson, et al	B.S.&F.Ry.Co. Sur.1, SW. cor.	10 mi. S. 4 W. Whiteland	1,401	2,050T	1,285	Log	765
White 1, Thomas, et al	Fisher and Miller Sur. 2586	1 mi. E. Whitehead	3,280	1,750T	1,008	Log	742
Zella 1, Prairie Oil & Gas Co	H. & T. C. Ry. Co. Sur. 89 SW. cor.	4 mi. NW. Lohn	3,466	1,500T	1,870	Log S. 2,050	-370

MILLS COUNTY

Name of Well and Owner	Location by Survey	Location from Town or Other Place	Total Depth	Surface Elevat'n	Depth Ellenb'rger	Kind of Record	Map Entry
Cryer 1, Mills County Oil Co.	J. M. Clark Sur. 14	12 mi. W. 5 N. Golthwaite	....	1,317	1,885	Log S. 1,885	-468
Harrison & Slayden 1, Venture Oil Co	T. Carroll Sur. 401	14 mi. W. 8 N. Golthwaite	3,065	1,271	1,540	Log	-269
Howel 1, Atlantic Production Co.	M. Kenedy Sur. 647	4½ S. 3 W. Golthwaite	2,440	1,228	2,007	Log	-779
Locklear 1, Texas Co.	Sam Cates	Golthwaite, 8 mi. W. 1 N.	2,715	1,248	2,035	Log	-787
Tyson 1, A. R. Forstner, et al.	T. & N. O. Ry. Co. Sur. 2	10 mi. W. 10 N. Golthwaite	2,520	1,372	2,320	Log S. 2,410	-948
Ware 1, Ware Haywood Oil Co.	H. Thurmester	6 mi. S. 1 E. Golthwaite	2,510	1,248	2,473	Log S. 2,505	-1,225
Weston 1, Clarion Oil Co.	Caldwell Co. Sch. Lds. Sur. 112	4¾ mi.W.1½ N.Golthwaite	2,400	1,338	2,118	Sam.	-780
Whittenburg 1, Stirling Oil Co.	A. Thompson Sur. 2	2 mi. E. Ebony	1,285	1,435	1,175	Log	260
Young 1, Fidelity Oil Co.	....	....	....	....	....	....	....

PALO PINTO COUNTY

Name of Well and Owner	Location by Survey	Location from Town or Other Place	Total Depth	Surface Elevat'n	Depth Ellenb'rger	Kind of Record	Map Entry
Abrams 1, Sinclair Gulf Oil Co.	Texas and Pacific Sur. 43	3½ mi. S. Mineral Wells	3,998	1,305	....	Log	-2,693+
Chestnut 1, Empire Gas & Fuel Co.	Geo. Green Sur. A-207, Cent. W. ½	8¼ S. 1½ W. Mineral Wells	4,210	1,122	....	Log	-3,088+
Dye 1, Roxana Petr. Co.	Tex. Emi. Lds. Co. Sur. 879	3¾ mi.fr.N.9½ fr.E.Co.line	3,933	940	....	Log	-2,993+
Edmondson 4, Empire G. & F. Co.	Daniel Bourn Sur. 46	7 mi.S. 1¼ W.Mineral Well	4,710	1,120	....	Sam.	-3,590+
McDonald 1, Texas Company	T. & P., Bl. 1, Sur. 31	2 mi. W. 1 S. Palo Pinto	4,665	1,033	4,635	Sam.	-3,602
Rogers & Rhea 1, Prairie O. & G. Co.	Sur. 166, SW. cor.	6¼ mi. E. Gorman	4,052	950T	....	Log & Sam.	-3,102+
Seaman, Roxana Petroleum Co.	T. & P., Bl. 3, Sur. 6	9½ fr. N.& 1 fr. W. Co. line	4,535	1,248	4,519	Log	-3,271
Smith 1	Johnson Bros.	2½ mi. E. Mineral Wells	4,392	847	....	Log	-3,545+
Watson 1, Empire Gas & Fuel Co.	Sur. 48	5 mi. W. 5 mi. N. Palo Pinto	4,053	979	....	Log	-3,074+

Name of Well and Owner	Location by Survey	Location from Town or Other Place	Total Depth	Surface Elevat'n	Depth Ellenb'rger	Kind of Record	Map Entry
RUNNELS COUNTY							
Russel 1, Gulf Prod. Co.	James Hughes	SE. part of county	3,505	1,677	3,448	Sam.	-1771
SAN SABA COUNTY							
Cummings 1, Coline Oil Co.	C. Herberg	3 mi. N. NE. Lockyer	1,380	1,362	805	Log S. 1,250	557
Heatherly 1, Duke & Knowles	Burchell Sur. 255	6 mi. N. ¾ E. Richland Spg	....	1,425T	605	Drl'ng Rpt.	820
SHACKELFORD COUNTY							
Nail 1, Benedum & Trees	E. T. Ry. Co. Sur. 50	10 mi. N. 2 W. Albany	4,465	1,525T	....	Sam.	-2,930+
STEPHENS COUNTY							
Bobo 1, Texas Pac. C. & O. Co.	T. P., Bl. 6, Sur. 67	2 mi. S. 1 E. Frankell	4,311	1,453	....	Log	-2,658+
Gaston 1, Texas Pac. C. & O. Co.	A. S. Johnston	S. side Brazos, 7 mi. from W. County line	4,650	1,131	4,650	Sam.	-3,519
Veale 1, Texas Pac. C. & O. Co.	T. P., Bl. 6, Sur. 74	6 mi. S. 2 E. Frankell	4,018	1,502	....	Log	-2,516†
YOUNG COUNTY							
Arnold 1, Texas Co.	....	10 mi. W. NW. Graham	4,711	1,270	....	Sam.	-3,438†

BARREL COSTS VS. WELL-DAY COSTS

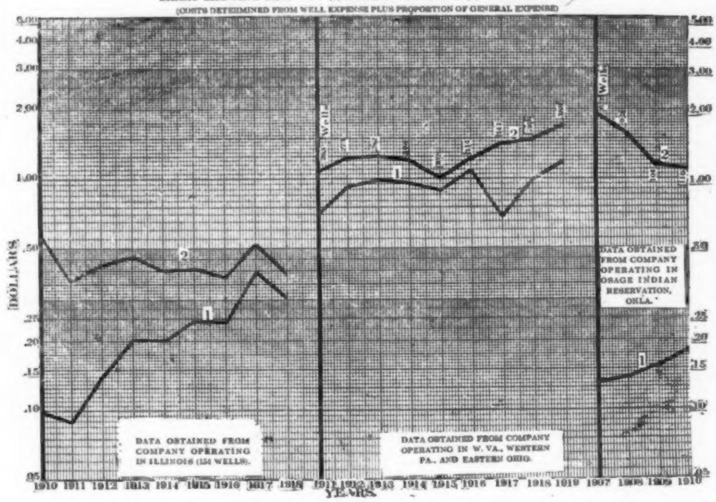
ROSWELL H. JOHNSON *and* A. W. FOSTER

An oil property is appraised by determining the net returns from the product and salvage, less costs and interest and allowance for risk. If the acre yield method is used for appraising, the past history of a district is used as a basis of comparison for similar properties in the same district where conditions are thought to be comparable. From this past history, barrel costs as well as acre yield are available and a flat rate barrel-cost averaged for the whole life may be determined and used. But where a property is appraised by the annual method, net annual returns are computed for a period of years by multiplying net production for each year by net barrel income for that year and then multiplying by the compound discount factor for that year to find the present worth for each year, and finally, totalling these present worth values and adding to discounted salvage value. Under these circumstances a flat barrel-cost rate, year to year, should not be assumed, for it cannot be the same through the life of the well, since wells increase in the cost per barrel, because there are fewer barrels in the later history among which to divide the maintenance of the well. To assume such a flat rate throughout the life will lead to gross error in the appraised value, an erroneous economic limit and therefore incorrect estimate of life. Costs per well-day (or costs per well-year) also change through a period of years, but are relatively constantly slowly advancing, even showing a decrease in one case, due to improved methods of extraction. They should therefore be used in preference to flat barrel costs, as the following evidence will show. Yet since for purposes of calculation we often need *barrel-day costs*, we can calculate them separately for each year by dividing the well-year costs, of any year, by the production of that year.

This matter seems important, since Bulletin 177 of the Bureau of Mines is being widely used, with its valuation example a flat barrel cost throughout the life of the property.

Roswell H. Johnson and A. W. Foster, University of Pittsburg, Pittsburgh, Pa.

CHART SHOWING TREND OF (1) BARREL COSTS AND (2) WELL-DAY COSTS
(COSTS DETERMINED FROM WELL EXPENSE PLUS PROPORTION OF GENERAL EXPENSE)



In obtaining the data to demonstrate this point another point of interest has developed. If the lease was all drilled up early, then maintenance costs should regularly increase per well-year although much less rapidly than barrel costs. The reason may safely be assumed to be increase of wages and costs of supplies. The late installation of a power may cause a sudden step downward in spite of the general advance.

So far, for simplicity, "operating costs" have alone been dealt with, excluding the share of general expenses and taxes.

When these are added to the well-year cost, as we should do, we find two interferences—the wave of high taxes caused by the war, and the fact that general expense (that portion chargeable to the old wells) is frequently reduced by the expense of the staff being divided over an increasing number of wells when the company is an expanding one. Some properties show a period of decline in well-year operating costs for a few years followed by a slow advance. If the property comes in with small initial production per well, this will be because of the extra labor necessitated till conditions are stabilized.

But if the property has a large initial production per well this

condition will usually be found to be the result of including in expense what are really deferred construction expenses, a not uncommon practice.

In conclusion, the purpose of this paper is to urge that in appraisals based on the annual analytic method (and we believe this is much better than the less reliable acre-yield method, both for tax and sale purposes) the barrel cost should change with the year, being calculated each year from the well-year cost of that year.

GEOLOGICAL PROBLEMS IN THE RECOVERY OF OIL AND GAS IN KENTUCKY

WILLARD R. JILLSON

Geologists are agreed that the chief problems which confront the oil and gas producer are (1) the source of the petroleum hydrocarbons, (2) the location of the pools, and (3) the most efficient methods of recovery. The average producer regards the first as largely a theoretical matter in which even those petroleum geologists who are the best qualified to speak are not fully agreed, and gives his attention only to the latter two. Yet bound up with the solution of the first problem is the real key to the science of petroleum geology. When the problems of original source have been solved many new indexes will be available in the discovery of new petroleum fields.

Kentucky contains the southernmost part of the great Appalachian oil and gas fields. Its problems are typical of this field, to which must be added those resulting from local differences in sedimentation. The geological problems associated with oil and gas recovery in the Eastern Coal Field of Kentucky are, with slight modifications, essentially those of West Virginia. These problems have to do with variations in structure, porosity, saturation, lensing, unconformity, faulting, sequence, lithology and depth of sediments, stage of regional metamorphism, devolatilization, degree of concentration, adequate cover and the respective combinations of these factors. In the consideration of any separate area in Kentucky, none of these factors may be disregarded, and while the absence of any of them would condemn a certain area, all of them taken together when inferred to be favorable may not be regarded as more than the separate earmarks of a productive locality.

From the standpoint of commercial values, two large areas in Kentucky must be designated as barren of petroleum and natural gas. These are (1) the Central Bluegrass area, and (2) the portion of western Kentucky which lies between Tennessee river on the southwest and Tradewater river on the northeast. A very large

---

Willard R. Jillson, State Geologist of Kentucky, Frankfort, Ky.

amount of drilling in the Bluegrass section has demonstrated the lack of commercial production here. The surface rocks of this region are Ordovician limestones, which are considerably jointed, faulted and mineralized. The absence of commercial petroleum and natural gas may probably be attributed to the lack of an adequate cover of shale. The widespread occurrence of small pockets of gas and occasional showings of oil throughout the area indicate that prior to the denudation of the Devonian cover, much larger quantities of oil and gas were present. The barren area in western Kentucky between Tennessee and Tradewater rivers is known as the faulted fluorspar region. The absence of commercial quantities of oil and gas in this section may be explained by the large amount of faulting and the accompanying devolatilization and rather high regional metamorphism.

One area, largely untested, which may possibly produce commercial quantities of oil and gas is the socalled Purchase Area, which lies between Tennessee and Mississippi rivers in the extreme western portion of the state. It comprises the head of the old Mississippi embayment. The surface rocks consist of sands, gravels, clays and marls of the Tertiary. They are underlain by unconsolidated and semi-consolidated Cretaceous and older sediments. The Cretaceous sediments, especially in the southwestern portion, might produce, but the area of faulting and igneous activity, which is conspicuous in the Mississippian exposures to the northeast in Kentucky and north in Illinois, may well extend under the greater part of this area and render these and lower sediments wholly unproductive. It may also be noted that this area is associated with the causes of the New Madrid earthquake. The relation of this disturbance to the possible productivity of oil and gas, while not definitely determined, may not be regarded as favorable.

With the exception of the three areas mentioned, all Kentucky may be considered important for prospecting for commercial oil and gas. This possible productive and producing territory comprises about three-fourths of the area of the state. It includes the Eastern and Western Coal fields and the area lying between them in which Mississippian and Devonian sediments are found at the surface. To this may be added a small area along Cumberland river in southern Kentucky near the Tennessee line where Ordovician sediments are exposed. Conditions in this areas were favorable for the

accumulation in disseminated form of the animal and vegetable source materials of petroleum during Ordovician, Silurian, Devonian, Mississippian and Pennsylvanian times. That there was a grouping of the animal and vegetable life and debris during these periods, resulting in areas of varying richness, and that there were some areas like the top of the Cincinnati anticline, which were land surfaces in Onondaga and Niagara times and therefore barren, cannot be doubted.

The area as a whole, however, was one of continuous or almost continuous deposition from the early Ordovician to the later Pennsylvanian. This eliminates many of the problems of original source. As a result of this almost unbroken sedimentation oil is secured in Kentucky in commercial quantities from sediments of the Ordovician, Silurian, Devonian, Mississippian and Pennsylvanian. Statements which have appeared to the effect that oil in Kentucky is principally Trenton oil are entirely fallacious. Trenton oil in Kentucky though present, is inconsequential both in quantity and value. About 95 per cent of the 9,226,473 barrels of oil produced in the state in 1919 came from the Devonian limestone which immediately underlies the Chattanooga black shale.

Each separate locality in Kentucky offers problems peculiar to that section. These problems have relatively little bearing in details upon those of the other producing fields of the state. The present commercially productive sections of Kentucky are: (1) the Allen-Barren-Warren county fields in southern Kentucky, (2) the Wayne-McCreary county fields in southeastern Kentucky, (3) the Estill-Lee-Powell-Wolfe-Menefee county fields, just southeast of the Central Bluegrass area, (4) the Lawrence county fields, (5) the Magoffin-Johnson county fields, (6) the Floyd-Knott-Pike-Knox county fields, and (7) the Martin county gas fields.

The Allen-Barren-Warren county fields produce chiefly from the Niagaran limestone of the Silurian and the Onondaga or "Corniferous" limestone of the Devonian. The oil occurs in porous parts of the limestone, no true sands being present. Structure is apparently an important consideration in such pools as the Moulder and Gainesville districts. Oil production occurs on the sides and tops of the anticlines and domes. However, in southern Allen county, good production is frequently found in synclines as well as anticlines, and in this locality the Niagaran limestone is the chief producer. In

southeast Barren county there are good structures, the upper parts of which contain gas or are dry, the oil appearing to be almost synclinal. In northwestern Barren and in Warren county the Fort Payne (Lower Mississippian) contains true sand lenses which produce a high grade of amber oil. While in some cases structure is important in this horizon, it is more generally a problem of feeling out the extent of the lens.

The Wayne-McCreary county fields are rather old, this being in fact, the district in which oil was first found in the state. This was in 1819 on the south fork of Cumberland river, the oil coming from Mississippian rocks at shallow depths. The Wayne-McCreary fields have been steady producers of high grade, light green oil. During the first quarter of 1920 it yielded 43,936 barrels. Production is secured from the Trenton and higher horizons of the Ordovician in the upper and lower Sunnybrook sands. It is also obtained from the Waverly group of sands, shales and limestones in the lower part of the Mississippian. These are the Stray, Mount Pisgah, Beaver, Otter, Cooper and Slickford sands. Well defined anticlines exist in Wayne county but here also the oil is not found high on the structure but rather well down on the slope or in the heads of the plunging synclines. Few reliable conclusions have been reached with respect to petroleum accumulations in the Wayne county district, and while structure is apparently important it is certainly not the main consideration or the only one. This is especially true of the irregular oil sands found in the Mississippian system. Their producing life is remarkable in length, but their variability in lithology and production, even in offset distance, is so striking that they cause drillers and geologists much confusion. These Mississippian sands are apparently connected or partially connected lenses which were formed by offshore currents during the period of deposition. They appear to connect with each other vertically as well as laterally, though it may reasonably be inferred that the vertical connection is much more restricted than the other. The Wayne-McCreary fields lie in a position which was offshore in the Mississippian seas, the mudstone clastics characteristic of the Waverly extending east and northeast and the increasingly calcareous beds of the Warsaw and Fort Payne reaching into southern and western Kentucky. It must have been an ideal locality for the deposition of carbonaceous debris giving rise to an area rich as a source of petroleum. In its irregular

sedimentation, however, it presents to the driller and geologist many unsolved problems.

The Estill-Lee-Powell-Wolfe-Menefee county district isthe greatest oil and gas producing section of Kentucky. Production is principally secured from the Onondaga limestone. This limestone is frequently called the Irvine, Ragland, Menefee, Campton, and Cannel City sand, but it is in reality simply a dolomitic limestone, the oil being obtained from the porous interspaces of the limestone. The oil is green in color, of high gravity and under relatively little pressure. While structure is present in this field it is apparently not the principal factor in production. The oil is found concentrated in porous parts of the limestone even where it is semi-synclinal, though it also occurs in the higher positions, as does the Menefee gas where porosity permits. The production in this district has been so great (about 8,500,000 barrels in 1919, or 90 per cent of the entire production of the state) as to raise pertinent question as to its source. By many geologists the oil is supposed to have originated in the Chattanooga black shale. The writer has never been able to agree with this view, but believes the oil to be original to the limestone, or in part derived from subjacent limestones.[1] This is evidenced by the drilling into considerably deeper production in the continuous limestone and shaly limestone series in the heart of the Big Sinking pool of Lee county.

The Lawrence county oil fields, while small in geographic distribution and certainly not large in production, are nevertheless of considerable interest. The oil, which is high grade and light amber to green in color, is produced from the Berea and Wier sands of the Lower Waverly in the Mississippian. The general structure of Lawrence county is that of a head of a deep synclinal trough plunging to the northeast into West Virginia. A number of the productive areas in Lawrence county occur well down in this trough, but newer fields are being developed high on the monoclinal fold to the southwest which is a limb of the pronounced Paint Creek uplift. The Berea and Wier oil of this section exhibits the characteristics of all the Mississippian oil of Kentucky, lightness in gravity and color, and a relatively low content of sulphur. The producing horizons

[1]Jillson, W. R.: New oil and gas pools of Allen county, Mineral and Forest Resources of Kentucky, Ser. 5, Vol. 1, No. 2.

of this county in both instances are true siliceous sands both of which as well as the overlying and underlying shales may have been contributing sources of the now contained petroleum and natural gas.

The Johnson-Magoffin county oil and gas fields, located on the crest and sides of the Paint Creek uplift on the Johnson-Magoffin county line, is perhaps the newest and one of the most 'nteresting fields in Kentucky. In this locality the Pottsville, Big Injun, Wier sands and the Onondaga limestone are all petroliferous. Commercial production is secured, however, only from the Wier sand. This sand is correlated with the Cuyahoga sandstone in the lower part of the Waverly. It is separated in this section by a shale body from the overlying Berea which is here commercially unimportant. The reason for the lack of commercial production in the Berea has not been satisfactorily explained, as it lies so close to the Lawrence county productive fields. Partial saturation of the Berea is perhaps the chief factor. Structure is, however, a principal consideration in the Paint Creek field, the oil occurring on the sides of the Paint Creek dome, the top being decidedly gassy. The Paint Creek dome lies as a faulted cap on the elongated north and south Paint Creek uplift. It is a relatively large structure, the productive portions of which might have been supposed, as mapped on surface Pottsville coals, to have been rather extensive. It was found, however, in drilling, that there were inequalities in thickness of the various sediments. The interval between the top of the Big lime (St. Louis-Ste. Genevieve) and the Wier sand appears to be greater at progressive distances east and west of the main structure, and to a lesser degree to the north and south. The folding of the Wier sand is much sharper than that of the surface coals. This explains many of the problems connected with the location of producing wells on this structure[2].

The Floyd-Knott-Pike-Knox county fields, though disconnected geographically, present a unit problem in that production is secured from the Pottsville of the Pennsylvanian and the Maxon of the Mauch Chunk. The position of these pools is geosynclinal, but minor structure have influenced to some degree the accumulation. In the Pottsville, as well as in the Mauch Chunk, relatively small amounts of water are responsible for the low position of the oil.

[2] Jillson, W. R.: A Mississippian island in the Mauch Chunk of eastern Kentucky, Geol. Sec., A. A. A., Sci., St. Louis meeting, Dec., 1919.

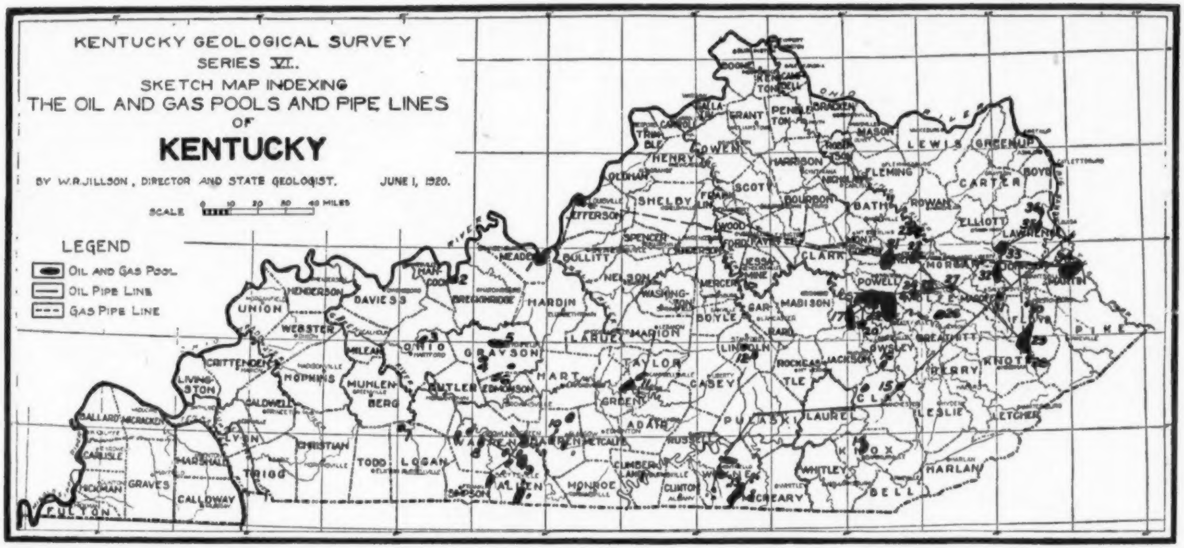
In Knox county the oil is found along rather narrow belts on minor structures, and in Floyd and Knott counties, synclines at the head of a synclinal trough. The gas of Floyd county, however, is anticlinal. Since both of the productive sands in these fields are siliceous (in some cases conglomeratic) sandstone, the lasting qualities of these sands has been very great. Some of the wells in the Floyd county Beaver Creek field have produced for more than twenty years. The oil is green, high gravity and relatively low in sulphur. In this district, as in Lawrence county, the producing oil sands may be regarded as at least a part of the original source.

In the Martin county gas field the producing horizons are the Big lime, and the Big Injun sand. The field is now an old one, useful for little more than reservoir purposes, but it has been an important one in the past twenty years, having furnished a large part of the commercial supply of gas for Louisville and other cities in West Virginia, Kentucky and Ohio. The productive horizons are true sands. The sand inclusion of the Big lime is relatively thin, but gives a rather high pressure gas, which suggests crevices or joint connections with the underlying Big Injun sand. Although a large amount of drilling has been done in this section and these sands have been penetrated at many points, relatively little oil has been found. However, one or two wells are reported to have flowed under strong head for a short time. The production of oil in Martin county is at present insignificant, 13 barrels being the entire reported production for the first quarter of 1920. In considering the problem of the absence of oil in this part of Kentucky recourse may be had to a study of the coals and carbon ratios as an index to the amount of regional metamorphism and devolatilization caused thereby. The Martin county district shows a rather high carbon ratio, as does the area to the south and southwest along the Pine Mountain fault, in Pike, Letcher, Harlan and Bell counties. From all this section of excellent Pottsville and Mississippian sediments no commercial quantities of oil or gas have been developed even after extensive drilling. Many showings of oil have been secured and gas in commercial quantities has been found, but a fixed carbon content, ranging from 64 to 66 per cent, giving a corresponding fuel ratio of 1.8 to 2.0 based on coals sampled at some little distance from the lines of greatest disturbance, is apparently indicative of

too great a regional alteration to permit the retention of oil, at least in commercial quantities.

The commercially important group of oil and gas pools now producing as indicated on the accompanying map are thirty-six in number and are as follows: (1) Meade County (Old) Gas Field; (2) Cloverport (Old) Gas Field; (3) Hardford Oil Pool; (4) Caneyville Oil Pool; (5) Leitchfield Oil and Gas Field; (6) Bear Creek Gas Field; (7) Diamond Springs Gas Field; (8) Warren County Oil and Gas Fields; (9) Allen County Oil and Gas Fields; (10) Barren County Oil and Gas Fields; (11) Greensburg Gas Field; (12) Lincoln County Oil Pools; (13) Wayne County Oil Pools; (14) Knox County Oil and Gas Fields; (15) Clay County Gas Fields; (16) Island Creek Gas Field; (17) Station Camp Oil Pool; (18) Irvine Oil Pool; (19) Big Sinking Oil Pool; (20) Ross Creek Oil Pool; (21) Menefee County Gas Field; (22) Menefee County Oil Pool; (23) Ragland Oil Pool; (24) Campton Oil Pool; (25) Still Water Oil Pool; (26) Breathitt County Gas Field; (27) Cannel City Oil and Gas Pool; (28) Knott County Oil Pool; (29) Beaver Creek Oil and Gas Fields; (30) Prestonsburg Oil and Gas Fields; (31) Burning Fork Gas Field; (32) Paint Creek Oil and Gas Field; (33) Laurel Creek Oil and Gas Field; (34) Martin County Gas Field; (35) Bussyville Oil Pool, and (36) Fallsburg Oil Pool.

Any brief consideration of so large a geographic unit as the State of Kentucky must necessarily overlook many of the smaller though none the less interesting geologic problems which bear close relationship to the recovery of petroleum and natural gas. Important among these is the cause of the low gravity and asphaltic base of the Ragland or Bath County oils, and the Lincoln County oils. These pools as is well known are very shallow, and yet devolatilization alone may not be ascribed as the single cause since other pools in close proximity producing from the same Devonian limestone, and at a similar depth give high gravity, green oil. The Allen, Barren, Warren field exhibits in most of the production secured from below the Black (or Chattanooga) shale from either the Devonian or Silurian limestone, a relatively high percentage of sulphur. This is the same horizon that produces the sweet, green oil of the Estill-Lee-Powell-Wolfe-Menefee section. The reason for the difference is an unsolved problem. In Grayson, Ohio, McLean, Webster, and Union counties, along the Rough Creek anticline and fault, similar structural


KENTUCKY GEOLOGICAL SURVEY
SERIES VI.
SKETCH MAP INDEXING
THE OIL AND GAS POOLS AND PIPE LINES
OF
KENTUCKY
BY W. R. JILLSON, DIRECTOR AND STATE GEOLOGIST.
JUNE 1, 1920.
SCALE
0 10 20 30 40 MILES
LEGEND
OIL AND GAS POOL
OIL PIPE LINE
GAS PIPE LINE
UNION
HENDERSON
DAVIESS
WEBSTER
CRITTENDEN
LIVINGSTON
HOPKINS
CALDWELL
MUHLENBERG
OHIO
GRAYSON
BUTLER
EDMONSON
HART
HARDIN
BRECKINRIDGE
MEADE
BULLITT
JEFFERSON
OLDHAM
HENRY
TRIMBLE
CARROLL
GALLATIN
BOONE
KENTON
GRANT
PENDLETON
BRACKEN
MASON
LEWIS
GREENUP
BOYD
CARTER
ELLIOTT
LAWRENCE
MORGAN
ROWAN
FLEMING
BATH
HARRISON
SCOTT
BOURBON
CLARK
POWELL
MADISON
WOODFORD
SHELBY
SPENCER
NELSON
WASHINGTON
MERCER
BOYLE
GARRARD
LINCOLN
MARION
LARUE
TAYLOR
CASEY
GREEN
ADAIR
RUSSELL
PULASKI
LAUREL
ROCKCASTLE
JACKSON
OWSLEY
BREATHITT
CLAY
KNOX
WHITLEY
BELL
HARLAN
LESLIE
PERRY
KNOTT
LETCHER
PIKE
FLOYD
MARTIN
MAGOFFIN
WAYNE
CLINTON
CUMBERLAND
MONROE
METCALFE
BARREN
WARREN
ALLEN
SIMPSON
LOGAN
TODD
CHRISTIAN
TRIGG
LYON
CALLOWAY
MARSHALL
GRAVES
CARLISLE
HICKMAN
BALLARD
McCRACKEN
FULTON
McCREARY
McLEAN
OHIO RIVER

conditions are found to those in eastern Kentucky along the Irvine-Paint Creek fault. In fact these two lines of disturbance with the connecting link of the deformation in central Kentucky have been ascribed by Gardner[2] to a common source. Yet this large belt in western Kentucky gives no promise, outside of small quantities of oil in Ohio and Grayson counties, and two small gas fields in Grayson, of any comparison in productivity to the eastern Kentucky section.

[2]James H. Gardner: A stratigraphic disturbance through the Ohio Valley, running from the Applachian Plateau in Pennsylvania to the Ozark mountains in Missouri, Bull. G. S. A., Vol. 26, pp. 477-483, Dec., 1915.

POSSIBILITY OF OIL AND GAS IN MONTANA

J. P. Rowe

Search for oil and gas in Montana began about 1900. Some of the first wells are located in the Kintla Lake district, northern Flathead county, and the Browning or Swift Current field, about 80 miles north of Browning. In 1904 a well was drilled in southern Carbon county on a well defined anticline, but the crest of the anticline was in Jurassic rocks and no oil was encountered. Later, drilling was undertaken on the Glendive anticline in Dawson county, in the extreme eastern part of the state. A flow of gas sufficient to supply the town of Glendive was encountered and is at present used. About the same time, the city of Havre, in the northern part of the state, drilled a well almost within the town and secured a flow of gas which is still sufficient for domestic use in that city. Several other wells were soon drilled in the state, one or two of which at Baker, the county seat of Fallon county, secured commercial quantities of gas. In 1914 an unsuccessful well was drilled in the nearly flat country at Great Falls, where the Kootenai is the surface formation. This year witnessed oil excitement in the Sweet Grass hills district, where anticlinal structures of laccolithic origin offer opportunity for the accumulation of oil deposits. However, the rocks are cut by numerous dikes and no commercial quantities of oil or gas have been discovered.

In 1917 a test well was put down at a favorable point on the Glendive anticline. The company drilled to a depth of more than 4,000 feet, going through all of the known oil or gas formations. A flow of gas was encountered at one place, but no oil of commercial value was secured.

In 1918 a well was drilled at Laurel, Yellowstone county, and it was reported that a small amount of oil was encountered. As the formations are almost horizontal, a large amount of oil would not be expected. Several other rigs were in this district in 1918. Wells were drilled near Conrad and to the west in the Birch Creek (Sun

J. P. Rowe, Missoula, Mont.

River area) northwestern Montana. A well was drilled to a considerable depth in Carbon county about the same time, but without results. Many other wells have been drilled in the state, but up to 1919 no oil in commercial quantities had been found, except in Elk Basin. Wells were drilled at Two Dot, Wheatland county; Wilsall; in the Shields River valley, Park county; and also in the southern part of Stillwater county.

Oil was discovered in the Elk Basin field in 1915. This field, situated partly in Carbon county, Montana, and partly in Wyoming, yields a high grade of oil and is a good producer. It may be considered a part of the Wyoming oil territory.

Since 1919 several wells have been drilled, chiefly in Musselshell, Garfield and Fergus counties. At the present the country about Roundup for many miles has all been leased, except the land that has been withdrawn by the government. Recently a well on Sec. 24, T. 11 N., R. 24 W. brought in oil. This well is on the Devil's Basin anticline in Mussellshell county. There is much activity in this field. It has been reported also that a good flow of oil was struck on the Cat Creek anticline near Mosby in eastern Fergus county. There is much excitement in Roundup and smaller towns near by. Many well known concerns have already started operations.

GEOLOGY OF OIL DEPOSITS IN MONTANA

In Montana oil and gas in commercial quantities will probably not be found lower than the Upper Cretaceous. At several localities where structural conditions are favorable, the Upper Carboniferous is wanting. The eastern two-thirds of Montana is within the Great Plains region and the surface formations belong, for the most part, to the Tertiary or the Cretaceous (chiefly Colorado and Montana groups), and in small amounts in the Embar (Permian) and the Chugwater (Jurassic). The oil from the Cretaceous is a high grade, light, paraffin oil; that from the older formations, a black asphaltic oil. In Alberta, at Medicine Hat in southern Manitoba, gas has been obtained from about the horizon of the Niobrara, and at Bow Island and Pelican Rapids on the Athabaska, from the horizon of the Dakota[1], or perhaps the lower part of the Colorado shale[2].

Because of its association with the Colorado shale the Virgelle sandstone may contain oil or gas in northern Montana. According

[1]Dowling, D. B., Can. Geol. Survey, Mem. 52, Geol. Ser. 42.
[2]Stebinger, E., U. S. Geol. Survey, Bull. 641.

to Stebinger the large production at Medicine Hat and the gas obtained at Havre come from this sandstone.

From a geological standpoint, conditions are practically the same in Wyoming, Montana and Alberta. The geologic formations which contain much oil in Wyoming and abundant gas in Alberta are found in Montana. Since it appears that Montana geological formations were laid down under conditions similar to those in Wyoming and Alberta, it may be concluded that where structures and other conditions are favorable there is reasonable expectation of finding oil or gas.

The Kootenai formation appears to be the lowest formation which offers oil or gas possibilities in the state. Above the Kootenai is the Colorado shale, containing in its lower half a number of sandstone beds. The Colorado formation is probably of first importance as a possible source of oil and gas in Montana.

Above the Colorado shale throughout north central Montana there is a group of sandy beds from 250 to 400 feet thick, which constitutes the Eagle sandstone. The lower half is known as the Virgelle sandstone member. The Havre, Montana and Medicine Hat, Alberta, natural gas comes from the Eagle sandstone. The higher and lower formations are probably more or less barren.

It is very probable that in Montana large quantities of gas or oil will be found, if at all, only in strongly developed folds, with relatively high dips, such as those in Wyoming, rather than in folds having very low dips, such as are characteristic of the Midcontinent fields. This belief is based on the fact that most of the oil fields so far developed in the Cretaceous rocks of the region adjacent to the Rocky Mountains, from Colorado to Alberta, are on strongly developed anticlines. There seem to be no conditions present in Montana which will make that state an exception to the general rule for the Rocky Mountain and Great Plains fields[3].

In the writer's judgment, Montana has a good future in the production of natural oil and gas. Another year will throw much light upon the subject. At present the central part of the state seems to offer a more promising field for the oil prospector than any other part, although few localities have been throughly and carefully tested by the drill.

---

[3]Stebinger, E., U. S. Geol. Survey, Bull. 641.

PROCEEDINGS OF THE FIFTH ANNUAL MEETING

OF THE

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

Held at Dallas, Texas, March 18 to 20, 1920.

The headquarters of the American Association of Petroleum Geologists during the fifth annual meeting were at the Adolphus Hotel. The Thursday sessions were held at the City Temple, and the one on Friday morning at the Municipal Building, all others being held in the Junior Ball Room at the Adolphus.

At the opening session, Thursday morning, the meeting was called to order by the president, Dr. I. C. White, State Geologist of West Virginia. Greetings were given by Mr. Saville, Secretary of the Dallas Chamber of Commerce, and by Robert T. Hill, President of the Southwestern Geological Society, after which papers on the oil resources and possibilities of New Mexico and Northwestern Texas were given. The titles of all papers will be found in the Table of Contents. The program included a survey of many of the producing fields, and a number of papers on technical subjects, and all were ably handled and enthusiastically received.

On Thursday evening the Association and citizens of Dallas were given the privilege of hearing Dr. George Otis Smith, Director of the United States Geological Survey, in an address on "The Public Service Opportunity of the Oil Geologist." The social features of the meeting were an informal reception and smoker, following Dr. Smith's address, at which he was the guest of honor; a luncheon on Thursday, and a buffet luncheon and social gathering on Friday evening, at the Adolphus.

The business of the Association was transacted on Friday afternoon and Saturday morning. The President, Dr. White, gave a brief review of the progress of the Association during the year. The report of the Secretary-Treasurer, Dr. Charles E. Decker, was given. Included in this report were recommendations concerning the appointment of standing committees, and later, on a

motion by Roswell Johnson, the appointment of these committees was adopted.

The Editor, Charles H. Taylor, reported that 1,000 copies of Volume III had been printed, 400 being bound in cloth covers and the rest in paper. Owing partly to the unsettled labor conditions and the delay in forwarding manuscript, the Bulletin was not ready for distribution until about the middle of January. Copies were then mailed to all members, but eight copies were returned to the editor because the postoffice had no forwarding address. The supply of bound copies was reported exhausted, and 100 copies each of Volumes I, II, and III had been ordered bound. The supply of Volume I is almost exhausted.

The committee on securing a suitable emblem for the Association reported that no definite decision had been reached, and after further discussion it was voted not to adopt any emblem.

The following resolution was presented by E. G. Woodruff:

"Whereas, we, the American Association of Petroleum Geologists, believe that geologists occupy an important place in the petroleum industry, and are responsible to many investors who are unable to judge of the qualifications of geologists;

"Whereas, we feel that regularly qualified geologists are not now sufficiently protected from unqualified and unscrupulous men practicing geology, therefore, be it resolved that efforts be made in every state in which petroleum is produced to obtain laws requiring that practicing geologists be licensed; that a condition of such licensing be that the applicant be a graduate of a school of recognized standing; that he be required to have two years or its equivalent of field work under a licensed geologist; and that he satisfy a qualifying board of his qualifications and ability before such license is issued."

After considerable discussion, the resolution was referred to a committee of ten, F. W. DeWolf, State Geologist of Illinois, chairman, and after careful consideration the following recommendation was offered:

"It is the sense of your committee that it is both unwise and impractical to secure a discriminative classification of petroleum geologists and engineers by legislative means. It is also the view of the committee that the object can best be obtained by careful attention to standards of membership in this Association, and the enforcement of them, as well as the proper enforcement of discipline among its members. It is recommended that a list of the members of the Association, with a concise record of training and experience, be published, together with a brief statement of the object of the Association and the qualifications for membership.

"It is further recommended that those finding it desirable to employ geologists of whose professional qualifications they are not fully informed, consult either the

United States Geological Survey, or their own State geologist, or the secretary of the American Association of Petroleum Geologists for the purpose of securing necessary information."

These recommendations were approved and adopted by the Association.

The following amendments and additions to the consititution and by-laws were presented by W. E. Wrather, and referred to a committee of which Mr. Wrather was appointed chairman, who reported favorably and recommended a complete discussion at the time of their proposed adoption, which will be at the annual meeting of 1921. The recommendations were adopted.

"Article III, Sec. 1. Any person actively engaged in the work of petroleum geology or in research pertaining to petroleum geology or techology is eligible to active membership in the American Association of Petroleum Geologists, provided he is a graduate of an institution of collegiate standing, in which institution he has done his major work in geology, and has subsequently had the equivalent of three years' field experience in petroleum geology; and provided further, that in the case of an applicant for membership who has not had the required collegiate or university training, but whose standing in the profession is well recognized, he shall be admitted to membership when his application shall have been favorably and unanimously
1921 acted upon by the executive council. And provided further, that these requirements shall not be construed to exclude instructors and professors in recognized institutions whose work is of such a character as in the opinion of the executive committee shall qualify them for membership.

"Sec. 4. Associate members shall enjoy all the privileges of membership in the Association save that they shall not hold office, sign applications for membership, or vote in business meeting.

"Sec. 5. Each applicant for membership shall be formally notified in writing, by the secretary of his election, and shall be furnished with a membership card for the current year; and until such formal notice and card are received he shall in no way be considered a member of the Association.

"Sec. 6. Application for membership may be accepted at any time, but unless an applicant shall have his application approved and have been formally notified by the secretary of his election at least one month before the annual meeting, he shall not be allowed to participate in the business session of said annual meeting.

"Sec. 7. The officers elect shall assume the duties of their respective offices one month after date of election.

"Article VIII. Sec. 1. Regional sections of the Association may be established provided the members of such sections shall perfect a regional organization and make application to the executive council, who shall submit the application to a vote at the regular annual meeting; a vote of two-thirds of the members present being necessary for the establishment of such section, and provided that the Association may revoke the charter of any section by a vote of two-thirds of the membership.

A motion favoring the establishing of such sections was passed.

BY-LAWS. "SEC. 2. Any member who shall fail to pay his regular annual dues for a period of one year may be suspended by a vote of the executive council, but may be reinstated upon the unanimous consent of the council.

"SEC. 4. Any member who shall be guilty of a flagrant violation of the established principles of professional ethics may upon the unanimous vote of the executive council be suspended from membership, provided that such a person shall before suspension be granted a hearing before the entire executive council."

The following amendment was presented and referred to the committee on amendments:

"No papers shall be presented at the annual meeting unless a complete copy of same be in the hands of the executive committee one month before the meeting."

Three resolutions presented by W. E. Wrather were adopted:

"FIRST. Resolved: That it is the sense of this Association that its members report to the executive council any knowledge they may have of any practices on the part of members not in keeping with the ordinarily accepted principles of professional ethics. Such report shall be held in absolute confidence, and shall be made without prejudice to the member making such report.

"SECOND. Resolved: That it is the sense of this Association that it does not countenance the practice of members advertising their membership in the Association in professional cards or in the signing of reports.

"THIRD. Resolved: That the executive council may use its discretion in releasing for prompt publication in current oil journals papers presented by members at the annual meeting, provided that due credit be given the Association."

The Association voted in favor of granting the Secretary-Treasurer a sum not to exceed $500.00 and expenses for 1919, and an annual salary of $600.00 and expenses.

Owing to the increasing cost of publication, and the importance of the Bulletins as a necessary source of revenue, it was decided by vote that the practice of furnishing free copies of the Bulletin should be discontinued.

After extended discussion of the method of publication of the Bulletin, it was decided to leave it in the hands of the executive committee as provided by the constitution.

Upon the recommendation of the committee on resolutions a unanimous vote of thanks was extended to the officers and all others who had helped to make the meeting a success; and in appreciation of the presence and distinguished services rendered by Dr. George

Otis Smith, director of the United States Geological Survey, he was unanimously elected to honorary membership.

After brief addresses by the retiring president, Dr. I. C. White, and by the incoming president, Wallace E. Pratt, the fifth annual meeting of the American Association of Petroleum Geologists was declared adjourned.

Officers elected for the ensuing year were:

President, Wallace E Pratt.
Vice-President, Alex. W. McCoy.
Secretary-Treasurer, Charles E. Decker.
Editor, Raymond C. Moore.

The following committees were appointed:

CONSTITUTION COMMITTEE:

Alexander Deussen, Houston, Texas.
James H. Gardner, Tulsa, Okla.
Clark Gester, San Francisco, Cal.
C. W. Washburne, New York City.
W. E. Wrather, Dallas, Texas.

WAYS AND MEANS COMMITTEE:

R. W. Pack, Dallas, Texas.
E. DeGolyer, New York City.
K. C. Heald, Washington, D. C.
J. Elmer Thomas, Chicago, Ill.
L. C. Snider, Bartlesville, Okla.

PUBLICATION COMMITTEE:

C. H. Taylor, Oklahoma City, Okla.
Eliot Blackwelder, Denver, Colo.
Roswell Johnson, Pittsburgh, Pa.

PROGRAM COMMITTEE:

W. R. Jillson, Frankfort, Ky.,
Applachian Division.

F. W. DeWolf, Urbana, Ill.,
Central Western Division.

Sidney Powers, Tulsa, Okla.,
North Mid-Continent Division.

John R. Suman, Houston, Texas,
South Mid-Continent and Gulf Coast Division.

Max W. Ball, Cheyenne, Wyoming,
Rocky Mountain Division.

Carl Beal, San Francisco, Cal.,
Pacific Coast Division.

MEMBERSHIP COMMITTEE:

R. C. Somers, Pittsburgh, Pa.,
Appalachian Division.

James H. Hance, Urbana, Ill.,
Central Western Division.

Richard Hughes, Tulsa, Okla.,
North Mid-Continent Division.

John Y. Snyder, Shreveport, La.,
South Mid-Continent and Gulf Coast Division.

T. S. Harrison, Denver, Colo.,
Rocky Mountain Division.

E. D. Nolan, San Francisco, Cal.,
Pacific Coast Division.

REPORT OF THE TREASURER

March 19, 1920.

RECEIPTS:

To balance from W. E. Wrather	$ 774.29	
To balance from C. H. Taylor	36.50	
		$ 810.79
To annual dues		2,601.14
To Separates		116.00
To Bulletins		467.26
TOTAL RECEIPTS		$ 3,995.19

DISBURSEMENTS:

By publication of Bulletins:		
By Total expense of 1918 Bulletins	$ 727.25	
By Printing and binding 1919 Bulletins	1,800.00	
By Engravings 1919 Bulletin	106.00	
By Mailing 1919 Bulletin	88.25	
		$ 2,721.50
By cost of Separates		130.50
By stationery and printing		105.18
By postage		66.69
By supplies		17.85
By messages (telephone and telegraph)		11.71
By typewriting		10.25
By drayage and express		1.57
By personal expense (fare to Oklahoma City)		3.05
TOTAL DISBURSEMENTS		$3068.30
By balance to new account		926.89
		$ 3,995.19

Respectfully submitted,

CHARLES E. DECKER,
Treasurer.

ACTIVE MEMBERSHIP

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

Abrahamson, Hjalmer	502 Texas State Bank Bldg., Ft. Worth, Tex.
Adams, H. H.	Box 69, Ranger, Tex.
Adams, Noah C.	1032 Mayo Bldg., Tulsa, Okla.
Adkins, W. S.	Bureau Economic Geology, Austin, Tex.
Albertson, Maurice M.	206 Kittrell Bldg., Shreveport, La.
Allen, E. G.	Roxana Co., Mineral Wells, Tex.
Allen, Walter J.	211 South Rea St., Roswell, New Mex.
Alvey, Glenn H.	526 Elizabeth St., Beaumont, Tex.
Ambrose, A. W.	Experiment Station, Bartlesville, Okla.
Ames, Edward W.	Box 691, Ft. Worth, Tex.
Anderson, Carl B.	42 Broadway, New York, N. Y.
Andresen, Lewis P.	Carter Co., Casper, Wyo.
Andrews, Sylvan H.	241 Kennedy Bldg., Tulsa, Okla.
Applin, Paul L.	812 Mrs. Dan Waggoner Bldg., Ft. Worth, Tex.
Armstrong, J. M.	Altamont, Kans.
Arnold, Ralph	Union Oil Bldg., Los Angeles, Calif.
Augur, Irving V.	512 Union League Bldg., Los Angeles, Calif.
Aurin, Fritz	Marland Co., Ponca City, Okla.
Baker, Chas. L.	2320 Hilgard Ave., Berkley, Calif.
Baker, Frank R.	Texas Co., Houston, Tex.
Ball, Max W.	Matador Pet. Co., Cheyenne, Wyo.
Ball, Sidney H.	42 Broadway, New York, N. Y.
Barton, Donald C.	Amerada Pet. Corp., 65 Broadway, New York. N. Y.
Barton, Louis A.	404 Hutchinson Bldg., Shreveport, La.
Bartram, John G.	Roxana Pet. Co., Tulsa, Okla.
Bateman, Alan	Yale University, New Haven, Conn.
Bates, Mowry	Atko Bldg., Tulsa, Okla.
Bauer, C. Max	McBrayer Bldg., Okmulgee, Okla.
Beal, Carl H.	523 Wells Fargo Bldg., San Francisco, Calif.
Bean, Ward C.	Empire Co., Burton Bldg., Ft. Worth, Tex.
Beck, Elfred	1445 North 21st St., Lincoln, Nebr.
Beede, J. W.	1711 San Antonio St., Austin, Tex.
Beekley, Albert L.	Box 1362, Tulsa, Okla.
Belt, Ben C.	Gulf Production Co., Gulf Bldg., Houston, Tex.
Bennett, Clyde M.	Louisiana Oil Ref. Corp., 1st Nat. Bank, Shreveport, La.
Bennett, Holly R.	New Domain Co., P. O. Box 1062, Dallas, Tex.
Berger, Walter R.	Emerald Oil Co., Winfield, Kans.
38 Bierman, Alfred C.	812 Dan Waggoner Bldg., Ft. Worth, Tex.

Birk, Ralph A. .... Box 583, Duncan, Okla.
Blackwelder, Eliot .... 317 Railway Exchange Bldg., Denver, Colo.
Blanchard, W. G. .... Marland Co., Ponca City, Okla.
Bloesch, Edw. .... Box 603, Okmulgee, Okla.
Borries, W. J. .... 33 Kenyon Bldg., Louisville, Ky.
Bostick, J. W. .... 621 Mason Bldg., Houston, Tex.
Bosworth, Thos. Owen .... Imperial Oil Co., Toronto, Canada
Bowen, James P. .... Temple, Okla.
Bowman, Wayne F. .... T. O. L. Dev. Co., Dallas, Tex.
Boyd, Harold E. .... Henry Doherty Co., 60 Wall St., New York, N. Y.
Boylan, Ebert E. .... Box 525, Edmond, Okla.
Brace, Orval L. .... 1210 Southwestern Life Bldg., Dallas, Tex.
Bradish, Ford .... Box 717, Breckenridge, Tex.
Brantly, John E. .... 612 Amer. Exchange Bldg., Dallas, Tex.
Bridge, S. D., Jr. .... 230 West Courtland Place, San Antonio, Tex.
Broman, Isadore J. .... 841 Kennedy Bldg., Tulsa, Okla.
Brown, J. Earle .... 509 Nat. Bank Commerce, San Antonio, Tex.
Brown, Robt. W. .... 4257 Gladys Ave., Chicago, Ill.
Bruyere, Alan .... Box 486, Cisco, Tex.
Bryan, Frank .... 305 Cosden Bldg., Tulsa, Okla.
Burnett, Jerome B. .... 2500 Vine St., Lincoln, Neb.
Burress, Geo. H. .... 801 Colcord Bldg., Oklahoma City, Okla.
Burress, Walter M. .... Empire Co., Bartlesville, Okla.
Burt, Roy Allen .... Booth Bldg., Independence, Kans.
Burton, George E. .... 1216 Colcord Bldg., Oklahoma City, Okla.
Burtt, John G. .... Roxana Co., Arcade Bldg., St. Louis, Mo.
Bush, Reed D. .... Deputy State Oil & Gas Inspector, Taft, Calif.
Buttram, Frank .... 601 West 14th St., Oklahoma City, Okla.
Bybee, H. P. .... University of Texas, Austin, Tex.

Cadman, Wilson K. .... 155 Washington Ave., Edgewood, Pittsburgh, Pa.
Calvert, W. R. .... Newhouse Bldg., Salt Lake City, Utah.
Campbell, Margaret L. .... Roxana Petroleum Co., Arcade Bldg., St. Louis, Mo.
Cashin, D'Arcy M. .... 408 Goggin Bldg., Houston, Tex.
Caudill, Samuel J. .... 742 Kennedy Bldg., Tulsa, Okla.
Cheney, Charles A. .... 326 Mayo Bldg., Tulsa, Okla.
Cheney, M. G. .... 103½ West 6th St., Ft. Worth, Tex.
Clapp, Frederick G. .... 120 Broadway, New York City, N. Y.
Clark, Chester C. .... Empire Co., Drawer F, Bartlesville, Okla.
Clark, Clifton W. .... 3734 Spence St., Dallas, Tex.
Clark, Frank Rinker .... Sisterville, West Virginia
Clark, Glenn C. .... Marland Co., Ponca City, Okla.
Clark, R. W. .... McBrayer Bldg., Okmulgee, Okla.
Clark, Stuart K. .... Box 708, Okmulgee, Okla.
Cline, Justus H. .... Box 930, Cheyenne, Wyo.
Clinkscales, Albert S. .... Marland Co., Box 87, Howard, Kans.
Cook, Harold J. .... Agate, Nebr.

Collom, Roy E. ... 920 Fresno Ave., Berkeley, Calif.
Conkling, R. A. ... Roxana Co., Arcade Bldg., St. Louis, Mo.
Corbett, Clifton S. ... University Club, Madison, Wis.
Coryell, L. S. ... Phillips Pet. Co., Bartleville, Okla.
Cox, G. H. ... Rolla, Mo.
Cragoe, E. J. ... Box 501, Baldwin City, Kans.
Cullen, John ... Coleman, Tex.
Cumming, C. L. ... No address
Cummins, W. F. ... Rio Bravo Oil Co., Houston, Tex.
Cuttler, Willard W., Jr. ... 6 West Melrose St., Chevy Chase, Md.

Dalburg, Frank A. ... West India Oil Co., Caracas, Venezuela, S. A.
Dallas, Orlan L. ... 303 Kittrell Bldg., Shreveport, La.
Dallenger, F. A. ... Wichita Falls, Tex.
Dally, Claude F. ... 305 Baum Bldg., Oklahoma City, Okla.
Dangerfield, A. N. ... Box 413, Riverside, Calif.
Davies, Fred A. ... Box 1503, Lewistown, Mont.
Davis, Ralph E. ... Room 1409, Broadway, New York, N. Y.
Dawson, L. Ray ... Dawson Bldg., Oklahoma City, Okla.
Day, Clarence O. ... 621 East 5th St., North Platte, Nebr.
Decius, Courtney ... 28 Steuart St., San Francisco, Calif.
Decker, Charles E. ... University of Oklahoma, Norman, Okla.
DeGolyer, Everett ... 65 Broadway, New York City, N. Y.
Deussen, Alexander ... 504 Stewart Bldg., Houston, Tex.
DeWolf, Frank W. ... State Geological Survey, Urbana, Ill.
Dissinger, Earl ... 716½ Louisiana St., Houston, Tex.
Dixon, A. Faison ... Room 1207, 90 West St., New York City, N. Y.
Dobbins, Chas. N. ... Box 1022, Ft. Worth, Tex.
Dodge, William ... 415 Highland Ave., Shawnee, Okla.
Donnelly, L. G. ... Room 1207, 90 West St., New York City, N. Y.
Donoghue, David ... Box 1357, Ft. Worth, Tex.
Donovan, Percy W. ... 730 Security Bldg., Minneapolis, Minn.
Doub, Charles O. ... 703 1st Nat. Bank Bldg., Tulsa, Okla.
Drake, N. F. ... Fayetteville, Ark.
Dresser, Myron A. ... Carter Co., Box 1262, Tulsa, Okla.
Drummond, Wallace G. ... S. W. Oil Dev. Co., Box 517, Eastland, Tex.
Dumble, E. T. ... 2003 Main St., Houston, Tex.

Easton, H. D. ... Youree Hotel, Shreveport, La.
Eaton, Arthur ... 1000 First Nat. Bank Bldg., Denver, Colo.
Eaton, Clayton H. ... Skirvin Hotel, Oklahoma City, Okla.
Eckes, Charles R. ... The Texas Co., Houston, Tex.
Edson, Frank A. ... State Geological Survey, Norman, Okla.
Ellenge, Geo. A. ... 513 Beatty Bldg., Houston, Tex.
Elliott, John E. ... 343 Sansome St., San Francisco, Calif.
Ely, Fred B. ... 208 Oil Operators Bldg., Ft. Worth, Tex.
Emmons, Wm. H. ... University of Minnesota, Minneapolis, Minn.

English, Leon E.	Sterling, Okla.
English, Walter A.	822 Citizens Nat. Bank Bldg., Los Angeles, Calif.
Estabrook, Edward L.	Midwest Refining Co., Casper, Wyo.
Fath, A. E.	U. S. Geological Survey, Washington, D. C.
Fees, L. V.	517 First Nat. Bank Bldg., Denver, Colo.
Ferguson, John L.	Box 471, Owensboro, Ky.
Ferguson, R. N.	Box 368, Taft, Calif.
Fettke, Charles R.	Carnegie Institute Technology, Pittsburgh, Pa.
Filmer, Edwin A.	44 Conklin Ave., Binghampton, N. Y.
Fischer, O.	1514 East 2nd St., Tulsa, Okla.
Fisher, Cassius A.	705 First Nat. Bank Bldg., Denver, Colo.
Ford, Carl S.	Champlin Refining Co., Enid, Okla.
Fohs, F. Julius	First Nat. Bank Bldg., Tulsa, Okla.
Forrester, Geo. A.	509 South Topeka St., Wichita, Kans.
Foster, Wm. H.	703 First Nat. Bank Bldg., Tulsa, Okla.
Friend, Russell D.	1646 Massachusetts Ave., Lawrence, Kans.
Fuqua, H. B.	Box 4, Duncan, Okla.
Galbraith, Thos. J.	608 Standard Oil Bldg., San Francisco, Calif.
Galpin, S. L.	Iowa State College, Ames, Iowa
Gardner, James H.	626 Kennedy Bldg., Tulsa, Okla.
Garfias, Valentine R.	Doherty & Co., 60 Wall St., New York, N. Y.
Garner, Aubrey H.	Room 1207, 90 West St., New York, N. Y.
Garrett, Dan L.	826 Brady Bldg., San Antonio, Tex.
Garrett, Lovic P.	Gulf Prod. Co., Houston, Tex.
Garrett, S. G.	Humble Oil & Ref. Co., Houston, Tex.
Gartner, James L.	Box 1748, Tulsa, Okla.
Gaylord, E. G.	3020 Regent St., Berkeley, Calif.
Gester, George C.	617 Standard Oil Bldg., San Francisco, Calif.
Geyer, F. Park	Marland Co., Ponca City, Okla.
Giffin, Wilson C.	Box 1295, Station A, Lincoln, Nebr.
Glenn, L. C.	Vanderbilt University, Nashville, Tenn.
Goldston, Walter L., Jr.	McCoy, Shidel & Pasewalk, Bartlesville, Okla.
Goodrich, Harold B.	111 West Fourth St., Tulsa, Okla.
Goodrich, Robt. D.	Gladys Belle Oil Co., Tulsa, Okla.
Gouin, Frank	Atlantic Co., Amer. Exc. Nat. Bank, Dallas, Tex.
Gould, Charles N.	1218 Colcord Bldg., Oklahoma City, Okla.
Graham, Edwin S.	Graham, Tex.
Gray, Alfred	Atlantic Prod. Co., Houston, Tex.
Grebin, Frederick C.	Bender Hotel, Houston, Tex.
Greene, Frank C.	30 North Yorktown St., (or Nebraska Bldg.), Tulsa, Okla.
Green, Geo. L.	Amer. Engineering Oil Corp., New York, N. Y.
Griswold, Clyde T.	804 Colcord Bldg., Oklahoma City, Okla.
Grove, Ivan H.	Address unknown
173 Hager, Dorsey	Guaranty Bldg., 44th & Fifth Ave, New York, N. Y.

Hager, Lee .... 502 Beatty Bldg., Houston, Tex.
Hall, Roy H. .... 1601 East Broadway, Columbia, Mo.
Hamilton, Chas. W. .... Apartado N' 106, Tampico, Tamps., Mexico
Hamilton, H. L. .... 609 Carter Bldg., Houston, Tex.
Hamilton, W. R. .... 729 Kennedy Bldg., Tulsa, Okla.
Hammill, Chester A. .... 1417 Amer. Exc. Bank Bldg., Dallas, Tex.
Hance, James H. .... State Geological Survey, Urbana, Ill.
Harnsberger, T. K. .... Roxana Co., Box 930, Cheyenne, Wyo.
Harrison, Thos. S. .... 1000 First Nat. Bank Bldg., Denver, Colo.
Hartley, Burton .... Lynch Bldg., Tulsa, Okla.
Hartman, Adolph E. .... 402 Milam St., Shreveport, La.
Hasbrouck, Bernard .... Cortez Oil Co., Tampico, Tamps, Mexico
Haworth, Erasmus .... University of Kansas, Lawrence, Kans.
Haworth, Huntman .... Conservative Oil & Ref. Co., ElDorado, Kans.
Hayes, Reese L. .... 310 South Frisco St., Tulsa, Okla.
Haynes, Winthrop P. .... 74 Beacon St., Hyde Park, Mass.
Hazeltine, R. S. .... The Greenwood Co., Wichita, Kans.
Heald, Kenneth C. .... U. S. Geological Survey, Washington, D. C.
Heaton, R. L. .... 305 Prince Theatre Bldg., Houston, Tex.
Hendon, Bryan .... 1129 North Beard St., Shawnee, Okla.
Hendry, Barbara A. .... 615 Shawnee Ave, Bartlesville, Okla.
Hennen, Ray V. .... Box 823, Morgantown, West Virginia
Henninger, W. F. .... Gulf Prod. Co., Box 1719, Houston, Tex.
Henning, John L. .... 525 Kirby St., Lake Charles, La.
Henry, Wm. W. .... 314 West 16th St., Tulsa, Okla.
Herald, J. M. .... 7204 Lindell Ave., St. Louis, Mo.
Herold, Stanley C. .... 1325 South Newport Ave., Tulsa, Okla.
Hill, Benjamin F. .... Cripple Creek, Colo.
Hill, Robert T. .... 612 Amer. Exc. Bldg., Dallas, Tex.
Hindes, E. P. .... Empire Co., Bartlesville, Okla.
Hinds, Henry .... 1153 Laurel Ave., St. Paul, Minn.
Hintze, F. F. .... 300 California Bldg., Denver, Colo.
Hodge, Edwin Thomas .... Holly Lodge, Vancouver, Canada
Holden, Wm. J. .... Parkersburg Cap's., Box 456, Parkersburg, West Virginia
Holman, Eugene .... 417-8 Merchants Bldg., Shreveport, La.
Honess, Charles W. .... Oklahoma Geological Survey, Norman, Okla.
Hook, Joseph S. .... Carter Oil Co., Tulsa, Okla.
Hoover, James E. .... 245 Lynch Bldg., Tulsa, Okla.
Hopkins, Edwin B. .... 512 Fifth Ave., New York City, N. Y.
Hopper, Walter E. .... 15 Heller Parkway, Newark, New Jersey
Howell, Jesse V. .... Box 487, Lawton, Okla.
Hubbard, Wm. Earle .... Humble Oil Co., Ardmore, Okla.
Hughes, Richard .... 902 Cosden Bldg., Tulsa, Okla.
Hughes, Urban B. .... Box 145, Cottonwood Falls, Kans.
Hughes, V. H. .... 326 Mayo Bldg., Tulsa, Okla.
Hull, Joseph P. D. .... Louisiana Oil Refining Corp., Shreveport, La.
Hummel, E. W. .... Care of G. W. Hummel, Mountain View, Okla.

Huntley, Louis G. .... University of Pittsburgh, Pittsburgh, Pa.
Hutchinson, L. L. .... Box 1515, Tulsa, Okla.

Iddings, Arthur .... 513 Wright Bldg., Tulsa, Okla.
Irwin, Joseph S. .... Box 448, Denver, Colo.

Jennings, Grace G. .... Marland Refining Co., Ponca City, Okla.
Jillson, Willard R. .... Old Capitol, Frankfort, Ky.
Johnson, Carlyle D. .... 515 East 18th St., Cheyenne, Wyo.
Johnson, Frederick A. .... 135 Breading Ave., Ben Avon, Pa.
Johnson, Roswell H. .... 1039 Murrayhill Ave., Pittsburgh, Pa.

Kautz, Archie R. .... Empire Co., Bartlesville, Okla.
Kay, Fred H. .... Twin State Oil Co., Tulsa, Okla.
Keeler, Clifton M. .... 4328 North McKinley Ave., Oklahoma City, Okla.
Kemp, James Furman .... Columbia University, New York City, N. Y.
Kendrick, Frank E. .... Lone Star Gas Co., Dallas, Tex.
Kennedy, Luther E. .... Sun Co., Box 1109, Dallas, Tex.
Kennedy, Wm. .... 2909 South Jennings Ave., Ft. Worth, Tex.
Kernan, Thos. H. .... Apartado 150, Tampico, Tamps., Mexico
Kesler, L. W. .... Empire Co., Bartlesville, Okla.
Kirby, Grady .... Mara. Explor. Co., Maracaibo, Venezuela, S. A.
Kirk, Charles T. .... 245 Lunch Bldg., Tulsa, Okla.
Kite, William C. .... 326 Baum Bldg., Oklahoma City, Okla.
Knapp, Arthur .... 230 Wall St., Shreveport, La.
Knappen, R. S. .... 1021 Maine St., Lawrence, Kans.
Knight, Samuel H. .... University of Wyoming, Laramie, Wyo.
Knox, John K. .... 1115 Missouri Ave., Houston, Tex.
Kraus, Edgar .... 105 McGowan Ave., Houston, Tex.
Kupferstein, Joseph T. .... Texas Co., Shreveport, La.

Lahee, Frederic H. .... 3607 Oak Lawn Ave., Dallas, Tex.
LaNeve, R. O. .... Box 434, Mineral Wells, Tex.
Lasky, Bernard H. .... Atco Bldg., Tulsa, Okla.
Lee, Marvin .... Union Nat. Bank Bldg., Wichita, Kans.
Lee, Wallace .... Frantz Corp., 611 17th St., Denver, Colo.
Leibensperger, R. .... Apartado 657, Tampico, Tamps, Mexico
Levorsen, A. Irving .... Box 664, Terre Haute, Ind.
Lewis, James O. .... Bureau of Mines, Washington, D. C.
Ley, Henry Alfred .... Standard Oil Co., Box 246, Jerusalem, Palestine
Liddle, Ralph A. .... Bureau Economic Geology, Austin, Tex.
Lilly, Eugene .... White Oil Corp., Wichita Falls, Tex.
Lindeblad, E. E. .... Empire Co., Bartlesville, Okla.
Logan, Clarence Z. .... Box 5, Clovis, New Mexico
Longmire, Wm. R. .... Box 617, Pawhuska, Okla.
Longyear, Robt. D. .... 710 Security Bldg., Minneapolis, Minn.
Loomis, Harve .... Skirvin Hotel, Oklahoma City, Okla.

LUCAS, A. F. .... 2300 Wyoming Ave., Washington D. C.
LUPTON, CHARLES T. .... 617 Gilpin St., Denver, Colo.
LYON, F. RUSSELL .... Empire Co., Bartlesville, Okla.

MACDONALD, DONALD F. .... 120 Broadway, New York City, N. Y.
MACKAY, HUGH .... 216 South Oak St., Sapulpa, Okla.
MCREADY, GEO. A. .... 343 Sansome St., San Francisco, Calif.
MARKHAM, EDMUND O. .... Carter Oil Co., Tulsa, Okla.
MARSTERS, VERNON F. .... J. E. Head Co., 312½ Texas St., Shreveport, La.
MARTIN, BRUCE G. .... Deceased
MATSON, GEORGE C. .... Gypsy Oil Co., Box 2044, Tulsa, Okla.
MATTESON, WALLACE G. .... 314 Texas State Bank Bldg., Ft. Worth, Tex.
MCCOLLOUGH, A. S. .... The Sun Co., Dallas, Tex.
MCCOY, ALEX W. .... 317 Johnstone Ave., Bartlesville, Okla.
MCCRARY, E. W. .... Tulsa, Okla.
MCFARLAND, R. S. .... 612 Amer. Exc. Bldg., Dallas, Tex.
MCINTIRE, PAUL J. .... Phillips Pet. Co., Bartlesville, Okla.
KCKEE, H. HARPER .... Room 1207, 90 West St., New York, N. Y.
MCLAUGHLIN, R. P. .... State Mining Bureau, San Francisco, Calif.
MCLEOD, ANGUS .... 717 W. T. Waggoner Bldg., Ft. Worth, Tex.
MCWHIRT, BURR .... Alama Pet. Corp., Box 243, Cisco, Tex.
MEREDITH, CARLTON .... Great Southern Life Bldg., Dallas, Tex.
MERRIT, J. W. .... Sapulpa Ref. Co., Box 1067, Ft. Worth, Tex.
MILLARD, WM. J. .... Rhodes Oil Syndicate, Woodward, Okla.
MILLER, ARTHUR M. .... University of Kentucky, Lexington, Ky.
MILLER, JOHN CHAS. .... Ponder & Pomeroy, Box 1583, Tulsa, Okla.
MINOR, H. E. .... Sinclair Co., Chronicle Bldg., Houston, Tex.
MONNETT, E. V. .... University of Oklahoma, Norman, Okla.
MONTGOMERY, H. R. .... 208 Nat. Bank Bldg., Muskogee, Okla.
MOODY, CLARENCE L. .... Ohio Oil Co., Winchester, Ky.
MOODY, WILBUR L. .... 1829 Berryman St., Berkeley, Calif.
MOORE, RAYMOND C. .... University of Kansas, Lawrence, Kans.
MORAN, ROBERT B. .... 458 South Spring St., Los Angeles, Calif.
MORGAN, DAVID MAX .... Marland Co., 215½ South Gordy St., El Dorado, Kans.
MORLEY, HAROLD T. .... Lone Star Gas Co., 1102 Amer. Exc. Bldg., Dallas, Tex.
MUNN, MALCOLM J. .... 305 Cosden Bldg., Tulsa, Okla.
MYERS, GEORGE H. .... Amerada Pet. Corp, Tulsa, Okla.

NASH, HOWARD F. .... National Pet. Corp., Apartado 285, Tampico, Tamps, Mexico
NELSON, WALTER S. .... 305-9 Finance Bldg., Kansas City, Mo.
NEUMAN, L. MURRAY .... Carter Oil Co., Tulsa, Okla.
NEWBY, JERRY B. .... 519 West 4th St., Oklahoma City, Okla.
NICKELL, C. O. .... Texas Co., Wichita Falls, Tex.
NISBET, JOHN M. .... Empire Co., Bartlesville, Okla
NOBLE, HOMER A. .... National Oil Co., Box 183, Shreveport, La.
NOLAN, EDWARD D. .... Shell Oil Co., Security Bldg., San Francisco, Calif.
NOTESTEIN, FRANK B. .... Box 295, Wooster, Ohio

OHERN, D. W. .... 515 West 14th St., Oklahoma City, Okla.
OLSSON, AXEL A. .... Sinclair Oil Co. of Louisiana, Shreveport, La.
OVERSTREET, JOHN B. .... Sun Co., Beaumont, Tex.
OWEN, EDGAR W. .... Beverly, Ohio
OWENS, ALLEN L. .... Carter Oil Co., Box 1262, Tulsa, Okla.

PACK, R. W. .... Sun Co., Box 1109, Dallas, Tex.
PANYITY, LOUIS S. .... 309 Nineteenth Ave., Columbus, Ohio
PARKER, EVERETT C. .... Box 716, Ponca City, Okla.
PEABODY, HARLAN W. .... Cosden Oil Co., Box 1362, Tulsa, Okla.
PEMBERTON, J. R. .... 729 Kennedy Bldg., Tulsa, Okla.
PEPPERBERG, LEON J. .... 910 Great Southern Life Bldg., Dallas, Tex.
PERKINS, JOSEPH M. .... 1218 Colcord Bldg., Oklahoma City, Okla.
PERRINE, IRVING .... 1415 West 31st St., Oklahoma City, Okla.
PETERSON, CLARENCE J. .... 729 Kennedy Bldg., Tulsa, Okla.
PETTY, DABNEY E. .... 503 Moore Bldg., San Antonio, Tex.
PISHEL, MAX A. .... 509 Bliss Bldg., Tulsa, Okla.
PLATA, BELISARIO .... H. Doherty & Co., 60 Wall St., New York, N. Y.
PLUMMER, F. B. .... 1511 Walnut Ave., Wilmette, Ill.
PORCH, EDWIN L., JR. .... Central Trust Bldg., San Antonio, Tex.
POWERS, SIDNEY .... 210 South Cheyenne St., Tulsa, Okla.
PRATT, WALLACE E. .... Humble Oil Co., Houston, Tex.
PRICE, SYLVAN S. .... 703 First Nat. Bank Bldg., Tulsa, Okla.
PROUT, F. S. .... 201 Brosius Bldg., Wichita, Kans.
PURDY, WESLEY .... Carter Oil Co., Room 1210, 26 Broadway, New York, N. Y.
PYLE, JAMES R. .... Marland Refining Co., Ponca City, Okla.

RADCLIFFE, D. H. .... 209-17 Magnolia Bldg., Oklahoma City, Okla.
RAE, COLIN C. .... 629 First Nat. Bank Bldg., Denver Colo.
RANDOLPH, E. OSCAR .... Box 286, College Station, Tex.
READ, M. K. .... 211 Barnes Bldg., Muskogee, Okla.
REED, RALPH D. .... Box 683, Henryetta, Okla.
REEDS, A. C. .... Coshen Oil Co., Box 1362, Tulsa, Okla.
REES, FOREST R. .... 46 North Zunis Ave., Tulsa, Okla.
REEVES, FRANK W. .... 801-2 Mrs. Dan Waggoner Bldg., Ft. Worth, Tex.
REGER, DAVID B. .... Box 816, Morgantown, West Va.
REYNOLDS, ROY A. .... Box 517, Eastland, Tex.
RICH, JOHN L. .... Argus Oil Co., Box 294, Iola, Kans.
RICHARDS, RALPH .... 2717 Connecticut Ave., Washington D. C.
RIDER, CHARLES R. .... Pierce Oil Co., 204 Mercantile Bldg., Oklahoma City, Okla.
RIGGS, ROBERT J. .... 617 Kennedy Bldg., Tulsa, Okla.
RING, DEWITT T. .... 703 First Nat. Bank, Tulsa, Okla.
ROARK, LOUIS .... Roxana Co., Wirt, Okla.
ROBERTS, JOHN R. .... Box 243, Eastland, Tex.
ROBINSON, J. FRENCH .... 831 Olive St., Shreveport, La.
ROBITAILLE, A. E. .... 522 Fifth Ave., New York City, N. Y.
ROCKWELL, FRED G. .... Oklahoma Geological Survey, Norman, Okla.

353

Rogers, Ola J. ..... Cleveland, Okla.
Rogers, Reese F. ..... 819 Palace Bldg., Tulsa, Okla.
Ross, Clarence S. ..... U. S. Geological Survey, Washington, D. C.
Rothrock, E. Paul ..... 801 Hippodrome Bldg., Cleveland, Ohio
Row, Charles H. ..... 826-7 Brady Bldg., San Antonio, Tex., and Garrett, Tex.
Rowe, J. P. ..... 341 Univeristy Ave, Missoula, Mont.
Russ, Leon F. ..... Albany, Tex.

Salisbury R. D. ..... University of Chicago, Chicago, Ill.
Sands, J. M. ..... Phillips Pet. Co., Bartlesville, Okla.
Scholl, Louis A., Jr. ..... Box 362, Tulsa, Okla.
Schramm, E. Frank ..... University of Nebraska, Lincoln, Nebr.
Schroeder, Rolf A. ..... 605 Temple Court Bldg., Chattanooga, Tenn.
Schuchert, Charles ..... Yale University, Hew Haven, Conn.
Schwarzenbek, Francis X. ..... U. S. Bureau of Mines, Bartlesville, Okla.
Scudder, E. W. ..... Emerald Oil Co., Winfield, Kans.
Sealey, Fred C. ..... 1435 Race St., Denver, Colo.
Segall, Julius ..... 404 Hutchinson Bldg., Shreveport, La.
Sellards, E. H. ..... University of Texas, Austin, Tex.
Semmes, Douglas R. ..... University of Alabama, University, Ala.
Severy, C. L. ..... 729 Kennedy Bldg., Tulsa, Okla.
Shannon, Charles W. ..... Oklahoma Geological Survey, Norman, Okla.
Shaw, Eugene W. ..... U. S. Geological Survey, Washington, D. C.
Shearer, Harold K. ..... Louisiana Oil Ref. Corp., Shreveport, La.
Shepard, Edward M. ..... 1403 Benton Ave., Springfield, Mo.
Shidel, Harold R. ..... 317-19 Johnstone Ave., Bartlesville, Okla.
Schuler, Ellis W. ..... Southern Methodist University, Dallas, Tex.
Sickler, Jack M. ..... Midwest Refining Co., Denver, Colo.
Simonds, Frederic W. ..... University of Texas, Austin, Tex.
Small, Walter M. ..... Box 1879, Tulsa, Okla.
Smith, Carl D. ..... Box 1136, Tulsa, Okla.
Smith, George Otis ..... U. S. Geological Survey, Washington, D. C.
Smith, Lloyd B. ..... 312 Levy Bldg., Shreveport, La.
Smythe, James J. ..... Box 625, Ranger, Tex.
Snider, L. B. ..... Oil Issues Co., 729 Kennedy Bldg., Tulsa, Okla.
Snider, L. C. ..... Empire Co., Bartlesville, Okla.
Snyder, John Y. ..... 1211 Merchants Bldg., Shreveport, La.
Somers, Ransom E. ..... 306 State Hall, Pittsburgh, Pa.
Souther, Helen I. ..... Empire Co., 615 Shawnee Ave., Bartlesville, Okla.
Spooner, W. C. ..... 402 Milam St., Shreveport, La.
Springfield, Carl K. ..... Box 427, Mansfield, La.
Stacy, Dean M. ..... 801 Colcord Bldg., Oklahoma, City, Okla.
Stander, Arthur E. ..... Texas Co., Box 362, Tulsa, Okla.
Stather, Silas C. ..... Standard Co., Box 1094, Shreveport, La.
Stauffer, C. R. ..... 1120 Fifth St., S.E., Minneapolis, Minn.
St. Clair, Stuart ..... Box 573, Bowling Green, Ky.
394 Stephenson, Eugene A. ..... South Pennsylvania Oil Co., Box 1255, Pittsburgh, Pa.

STEUBING, W. C. ... Helvetia Copper Co., 414 Nat. Bank Com., San Antonio, Tex.
STEVENS, GEORGE R. ... 609 Carter Bldg., Houston, Tex.
STEWART, IRVINE E. ... Box 1503, Bank Electric Bldg., Lewistown, Mont.
STEWART, P. CHARTERIS ... 51 Redcliffe Sq., So. Kensington, London, S.W., England
STUDT, CHARLES W. ... Gates Oil Co., Box 492, Yates Center, Kans.
SUMAN, JOHN R. ... 716 Southern Pacific Bldg., Houston, Tex.
SWIGART, THEODORE E. ... U. S. Bureau of Mines, Bartlesville, Okla.

TAFF, JOSEPH A. ... Southern Pacific Bldg., San Francisco, Calif.
TANSEY, V. O. ... 2826 East 76th Place, Chicago, Ill.
TARR, RUSSELL S. ... 309 Drexel Bldg., Tulsa, Okla.
TAYLOR, CHARLES H. ... 324 Baum Bldg., Oklahoma City, Okla.
THOMAS, C. R. ... 722 S. Boston St., Tulsa, Okla.
THOMAS, J. ELMER ... 751 First Nat. Bank Bldg., Chicago, Ill.
THOMPSON, A. BEEBY ... 18 St. Swithens Lane, London, S.E., England
THOMPSON, ROBT. R. ... 813 Mrs. Dan Waggoner Bldg., Ft. Worth, Tex.
TRAGER, EARL A. ... Ponca City, Okla.
TROUT, L. E. ... 305-7 Baum Bldg., Oklahoma City, Okla.
TRUEX, ARTHUR F. ... 902 Cosden Bldg., Tulsa, Okla.
TWENHOFEL, W. H. ... University of Wisconsin, Madison, Wis.

UDDEN, JOHAN A. ... University Station, Austin, Tex.
UDDEN, JON ANDREAS ... Box 1312, Room 506 Sinclair Bldg., Tulsa, Okla.
UMPLEBY, JOSEPH B. ... University of Oklahoma, Norman Okla.
URI, HUBERT N. ... 210 Tiger Bldg., Okmulgee, Okla.

VALERIUS, M. M. ... Mayo Bldg., Tulsa, Okla.
VAN DER GRACHT, W. A. J. M. VAN WATERSCHOOT ... Roxana Pet. Corp., Arcade Bldg., St. Louis, Mo.
VAN DER LINDEN, BERNARD H. ... University Club, San Francisco, Calif.
VANDIVER, VINCENT W. ... Carter Oil Co., Tulsa, Okla.
VAN WIJK, G. D. ... Box 542, Ardmore, Okla.
VEATCH, A. C. ... 260 Riverside Drive, New York City, N. Y.
VER WEIBE, WALTER A. ... Mexico Sinclair Co., Apartado 241, Tampico, Mexico

WRIGHT, HARRY F. ... 305 Cosden Bldg., Tulsa, Okla.
WAGENER, CHARLES H. ... 324 North Waller Ave., Chicago, Ill.
WAGNER, CARROLL M. ... 1001 Higgins Bldg., Los Angeles, Calif.
WAITE, V. V. ... Atlantic Co., Amer. Exc. Nat. Bank Bldg., Dallas, Tex.
WALKER, LUCIAN H. ... 1220 South Boulder Ave., Tulsa, Okla.
WALKER, W. L. ... 502 First Nat. Bank Bldg., Denver, Colo.
WARE, THOMAS T. ... 314 Bachelors Inn, Tulsa, Okla.
WARNER, CHARLES A. ... Empire Co,. Bartlesville, Okla.
WASHBURNE, CHESTER W. ... 66 Liberty St., New York City, N. Y.
WEAVER, PAUL ... Apartado 150, Tampico, Tamps, Mexico.
WEGEMANN, CARROLL H. ... Western States Oil Co., Drawer 240, Denver, Colo.
WEIDMAN, SAMUEL ... University of Oklahoma, Norman, Okla.

Wells, Samuel W. .... 812 Mrs. Dan Waggoner Bldg., Ft. Worth, Tex.
Welsh, Leroy G. .... Transcontinental Co., Box 1874, Tulsa, Okla.
White, David .... U. S. Geological Survey, Washington, D. C.
White, Edwin E. .... Graham, Young County, Tex.
White, I. C. .... State Geologist, Morgantown, West Va.
White, L. Ansel .... Clovis, New Mexico
White, Luther H. .... 219 East Jasper St., Tulsa, Okla.
Whitehead, R. Brooks .... Atlantic Co., 310 Amer. Exc. Nat. Bank, Dallas, Tex.
Whitney, F. L. .... University of Texas, Austin, Tex.
Whitwell, E. V. .... Box 851, Tulsa, Okla.
Williams, A. J. .... University of Oklahoma, Norman, Okla.
Williams, D. W. .... York State Oil Co., Caney, Kans.
Williams, W. A. .... H. Doherty Co., 60 Wall St., New York City, N. Y.
Winton, Will McClain .... Texas Christian University, Ft. Worth, Tex.
Wood, Robert H. .... 516 Daniel Bldg., Tulsa, Okla
Wood, Virgil O. .... 516 Daniel Bldg., Tulsa, Okla.
Woodruff, E. G. .... Oklahoma Producing & Refining Corp., Tulsa, Okla.
Woolsey, E. V. .... 728 South 18th St., Chickasha, Okla.
Wrather, W. E. .... 6044 Bryan Parkway, Dallas, Tex.
Wright, A. T. .... 322 Kennedy Bldg., Tulsa, Okla.
Wright, Fred S. .... Box 1503, Lewiston, Mont.

Young, L. J. .... Kansas Producing & Refining Corp., Box 313, Eureka, Kans.

ASSOCIATE MEMBERSHIP
AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

Absher, Wm. F. .... Norman, Okla.
Aylesbury, Dorothy G. .... 317-9 Johnstone Ave., Bartlesville, Okla.

Bell, Olin G. .... 304 South University Blvd., Norman, Okla.
Benton, Louis B. .... 1730 Sixth Ave., Ft. Worth, Tex.
Boswell, John S. .... 515 Burton Bldg., Ft. Worth, Tex.
Boyle, George R. .... 215 East 11th St., Oklahoma City, Okla.
Brown, Howard E. .... 1128 West 14th St., Oklahoma City, Okla.
Bullard, Fred M. .... Oklahoma Geological Survey, Norman, Okla.
Burg, Robert S. .... 3100 Travis Ave., Ft. Worth, Tex.

Cary, William T. .... Arkansas City, Kans.
Clarke, Archibald D. .... Box 188, Duncan, Okla.
Conder, H. H. .... Oklahoma Geological Survey, Norman, Okla.

Dean, David .... 2823 East 4th St., Tulsa, Okla.
Dean, Paul .... 2823 East 4th St., Tulsa, Okla.
Dewey, Robert S. .... 1218 Colcord Bldg., Oklahoma City, Okla.
Disney, Orville A. .... 220 North 15th St., Muskogee, Okla.

Dolphin, Adrian J. .... Lone Star Gas Co., Dallas, Tex.
Dorchester, Charles M. .... Gulf Prod. Co., Shreveport, La.
Dott, Robert H. .... 409 Fifth St., Sioux City, Iowa

Evans, Noel .... Marland Co., Ponca City, Okla.

Fitch, Frederika .... 318 College Ave., Norman, Okla.
Foster, Alden W. .... 461 Atlantic Ave., Pittsburgh, Pa.
Frantz, Esther F. .... Roxana Co., Arcade Bldg., St. Louis, Mo.

Goff, Lee B., Jr. .... 1340 West 17th St., Oklahoma City, Okla.
Greene, Ray G. .... Leitchfield, Ky.
Gretsinger, Wm. .... 1009 Davis Ave., Pittsburgh, Pa.

Hans, Oscar E. .... Marland Refining Co., Ponca City, Okla.
Hanson, Leslie C. .... 500 Reynolds Bldg., Ft. Worth, Tex.
Hardin, E. Glenn .... 719 West 17th St., Oklahoma City, Okla.
Henley, Arthur S. .... 609 Carter Bldg., Houston, Tex.
Hoffman, Charles C. .... 1217 Colcord Bldg., Oklahoma City, Okla.
Hood, Harold H. .... Lock Box 43, Litchfield, Ill.
Horn, Carl G. .... 1528 West 30th St., Oklahoma City, Okla.

Johnson, Russell V. .... 3015 Calhoun Ave., Minneapolis, Minn.

Kelsey, Jessie .... 127 North 9th St., Chickasha, Okla.
Kerr, John B. .... 411 Insurance Bldg., Dallas, Tex.
Kolm, Robert N. .... Atlantic Co., Amer. Exc. Nat. Bank Bldg., Dallas, Tex.

Laird, B. Leo .... 200 Bush St., San Francisco, Calif.
LaRue, James E. .... Humble Oil Co., Houston, Tex.
Linker, Sophie .... 970 Eastern Parkway, Brooklyn, N. Y.
Lively, Wm. P. .... 401 East Oklahoma Ave., Blackwell, Okla.
Lowe, H. J. .... 609 Carter Bldg., Houston, Tex.

Mason, Shirley L. .... 5554 Avondale Place, Pittsburgh, Pa.
McArthur, Donald .... McHenry, Miss.
McLellan, H. J. .... Humble Oil Co., Houston, Tex.
McNeese, Charles H. .... Marland Co., Ponca City, Okla.
Miller, Willard L. .... 2505 West 10th St., Oklahoma City, Okla.
Millikan, Chas. V. .... 208 Brushton Ave., Pittsburgh, Pa.
Morgan, Harold L. .... Tulsa, Okla.
Moyer, W. Irwin .... 3525 Forbes St., Pittsburgh, Pa.
Mulky, Francis P. .... 201 West 14th St., Oklahoma City, Okla.

Newby, Warner W. .... Sapulpa Ref. Co., Sapulpa, Okla.
Nichols, Charles R. .... Humble Oil Co., Cisco, Tex.

Orr, Milo M. .... 415 West 11th St., Oklahoma City, Okla.

PROBST, FREDRICA.....Roxana Co., Arcade Bldg., St. Louis, Mo.

RAMSEY, R. H.....509 Simpson Bldg., Ardmore, Okla.
ROBERTS, MORGAN E.....706 First Nat. Bank Bldg., Ft. Worth, Tex.
ROUNDY, P. V.....U. S. Geological Survey, Washington, D. C.

SAWYER, ROGER W.....Y. M. C. A. Bldg., Oklahoma City, Okla.
SCOTT, WALTER W.....609 Carter Bldg., Houston, Tex.
SMITH, EVAN.....Moore, Okla.
STAGGS, OLAN B.....802 West Main St., Enid, Okla.
STEINMAYER, R. A.....Amer. Exc. Nat. Bank Bldg., Dallas, Tex.
STILES, EDMUND B.....Bureau Economic Geology, Austin, Tex.
STORMS, WILLIS W.....Plains Oil & Gas Co., Box 296, Ardmore, Okla.
STOVER, JERRY S.....1118 Amer. Exc. Bank Bldg., Dallas, Tex.
STROUD, BEN K.....First Nat. Bank, Wichita Falls, Tex.

TATUM, JAMES L.....Apartado 150, Tampico, Tamps, Mexico
THOMPSON, VIRGIL A.....914 Monett Ave., Norman, Okla.
THOMPSON, WALLACE C.....Sun Co., Ardmore, Okla.
TWEEDY, JOSEPH L.....4406 Thomas Ave., Dallas, Tex.

UHRLAUB, RUDOLPH.....724 New Hampshire St., Lawrence, Kans.
UPHAM, HARRY R.....609 East High St., Mt. Vernon, Ohio

VERNON, JAMES I.....Coweta, Okla.

WALTERS, RAY P.....614 Nat. Bank Com. Bldg., San Antonio, Tex.
WARNER, J. LAIRD.....Ten Sleep, Wyo.
WATERS, VITA LEE.....Louisiana Oil & Ref. Co., First Nat. Bank, Shreveport, La.
WHEELER, CARLTON W.....Muldrow, Okla.
WITTEVEEN, G.....Carribean Pet. Co., Caracas, Venezuela, S.A.
WRIGHT, ANDREW C.....Care of James E. Wright, Baird, Okla.